AVIATION SAFETY
(Improving the Detection and Dissemination of Severe Weather Information to Pilots)

(100-47)

HEARING

BEFORE THE
SUBCOMMITTEE ON
INVESTIGATIONS AND OVERSIGHT
OF THE
COMMITTEE ON
PUBLIC WORKS AND TRANSPORTATION
HOUSE OF REPRESENTATIVES
ONE HUNDREDTH CONGRESS
FIRST SESSION

JUNE 30, 1987

Printed for the use of the
Committee on Public Works and Transportation

U.S. GOVERNMENT PRINTING OFFICE
85-331
WASHINGTON : 1988

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

H641-20

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AVIATION SAFETY

(Improving the Detection and Dissemination of Severe Weather Information to Pilots)

TUESDAY, JUNE 30, 1987

U.S. House of Representatives,
Subcommittee on Investigations and Oversight,
Committee on Public Works and Transportation,
Washington, DC.

The subcommittee met, pursuant to recess, at 9:42 a.m., in room 2167, Rayburn House Office Building, Hon. James L. Oberstar (chairman of the subcommittee) presiding.

Mr. Oberstar. The Subcommittee on Investigations and Oversight will come to order.

This morning we resume our inquiry into the impact of weather on aviation safety. Aviation weather is a phenomenon that has historically been of great interest to this subcommittee and, of course, everyone who flies. The first hearing the subcommittee conducted when it assumed responsibility for aviation matters in 1975 was an inquiry into approach and landing weather systems and phenomena.

Over the last twenty years, twenty-six civilian transport accidents involving wind shear caused some five hundred deaths. In the last decade and a half, six hundred people have died in aviation accidents caused by thunderstorms and wind shear.

The National Transportation Safety Board has documented that weather has been a causal factor in thirty-five percent of aviation accidents over a twelve-year period.

Some of the findings of those hearings include the need for more real-time weather information in the cockpit, especially in the terminal area. The Board recommended that weather information on the ground should be communicated to the aircraft. It found that all too often such information was not being communicated to the aircraft. And wind detection and alarm equipment is needed because accidents are caused by wind shear. During the five-year period 1975-1979, some four thousand persons lost their lives in weather-related aviation accidents.

Those are findings presented to the committee by former NTSB Chairman Jim King.

In 1981 and 1983 the subcommittee had a series of hearings to assess the Government's, and particularly FAA's, role and progress in addressing problems identified in earlier inquiries. It was very disturbing for the subcommittee to learn of the recurrence of many of the same types of weather-related accidents.

It was shocking to conclude again that real-time hazardous weather information was not reaching those who needed it the most: the pilots. In every weather-related airline accident discussed in those hearings, someone in the dissemination system knew of the hazard, but the individual who didn't know in every case was the pilot.

The purpose of our hearing today is to assess the state of the art of weather detection and dissemination. Those are the two keys: detecting it, and telling people about it.

Additionally, we will take a look at the status of several weather-related projects that have been under research and development for a number of years. Several recent developments have occurred which the subcommittee finds encouraging. We will hear about them today. Pilot training, an area that shows great promise for reduction of weather-related accidents. We will learn of a recently developed wind shear training aid program for pilots which stresses avoidance and recommends escape maneuvers in case of inadvertent encounters with wind shear.

We will hear about airborne wind shear detection systems that are available and in use today. We will learn about predictive systems that are under study.

We learned about a new and deadly weather phenomenon during our 1983 hearings, one that has gained increasing attention and about which we are learning more: microburst, an extraordinary phenomenon that works against the pilot's instincts and is a fearsome force that can be deadly, as we have seen.

Today we will learn about efforts to further characterize microbursts, to locate and avoid this most violent form of weather activity. Much remains to be done to ensure the timely detection and the timely dissemination of weather phenomena. Today we will explore the obstacles remaining in the implementation of improved detection systems. We are going to hear about terminal Doppler weather radar, about NEXRAD, and the feasibility of a direct ground-to-air data link so that pilots can directly receive the information they need most at the most critical time in the flight path.

It is obvious that there is very little that humans can do to affect weather. But it is also obvious and critically urgent that we do everything possible to help those fly to avoid the deadly consequences of adverse weather. That will be the subject of today's hearing.

The Chair recognizes the gentleman from Pennsylvania, Mr. Clinger, for opening remarks.

Mr. CLINGER. Thank you very much, Mr. Chairman. I would join with you in welcoming our witnesses who will be testifying and appearing before the panel today. I think we all look forward to what promises to be an educational and very productive session as we continue our inquiry into aviation safety as it is affected by hazardous weather.

I realize that much of the information the subcommittee is going to receive today will be of a highly technical nature, particularly as it describes weather detection and communication equipment. In truth, I am not sure which is more confusing; the systems and the equipment that we're dealing with, or the variety of acronyms which are used to describe them. As everyone realizes, however, it is that very equipment whose performance is so critical to pilots and passengers flying in hazardous weather conditions.

As I see it, the subcommittee's concern is two-fold: first, to ensure that the Federal money being expended on research, development, and installation of the latest technology is spent in a cost-effective fashion; and second, to reinforce the idea that weather detection technology alone is not enough, that the information received must be timely and understandably conveyed to the flight crew in the cockpit in time to be used effectively.

As you have indicated, Mr. Chairman, it is a basic truism that we can't do much about the weather. But Government and industry alike should do everything possible to help the flying public avoid its potentially tragic consequences.

Thank you, Mr. Chairman.

Mr. OBERSTAR. Thank you. I want to thank you and the staff on both sides of the aisle for splendid work in bringing together the elements of today's hearing.

Does the gentleman from North Carolina have an opening comment?

Mr. LANCASTER. No, Mr. Chairman. Thank you.

Mr. OBERSTAR. The gentleman from New York, Mr. Molinari?

Mr. MOLINARI. Thank you, Mr. Chairman. I just have a brief observation.

We did have exhaustive hearings back in 1981 and 1983, and we had a lot of expert testimony on the various problems relating to weather and aviation accidents. Not so long ago—I guess it was three or four months—we had some FAA officials testify before this subcommittee, and it was heartening, I guess, in one respect to hear one of the officials admit that because of the crash in Cerritos, California, FAA was responding with more speed to address the serious problems that surrounded that accident.

Then, in the course of questioning, I asked about the weather-related crash in Dallas, the Delta flight, and wasn't it a fact that because of that crash FAA was putting in place a series of innovations that would help make flying in bad weather safer for the passengers and more controllable for the pilot. There again we had a rather candid admission that day that that was the fact.

I can't help but make the observation as we begin these hearings that, if they looked back at the extensive hearings testimony in 1981 and 1983, as recorded by this subcommittee, there was some very sobering information there.

My own personal observation is that we could have avoided that crash in Dallas and saved a lot of lives. I only hope that we reach the point now where we are going to continue on that course.

It is a serious problem, and I will work together with you, Mr. Chairman and Mr. Clinger, to see if we can't fulfill our role in expediting the process. Thank you very much.

Mr. OBERSTAR. The Chair would like to acknowledge the pivotal role the gentleman from New York and my predecessor chairman of the subcommittee, Mr Levitas, in compiling documentation that is very thick on this subject. We wish only that we did not have to accompany that testimony in our hearing reports and our admonitions to the FAA and to others in the aviation sector with a long list of casualties as well.

The gentleman from Ohio?

Mr. McEwen. Thank you, Mr. Chairman.

I appreciate the opportunity to join in this hearing this morning and to state that I am pleased that you are addressing this very important subject once again. As you have mentioned, we have visited this situation before and observed the importance of the dissemination of lifesaving current weather information to pilots in a timely fashion.

Mr. Chairman, our research has discovered that this technology is readily available. This technology has produced a product that is currently on the shelves for automatic dissemination of current weather conditions to the pilots. This weatherization system has been patented since 1977, and the question that we need to continue to ask is why do the Federal Aviation Administration and other Government agencies continue research into development of an automated system when the weatherization system that we are seeking is currently available?

I would request permission, Mr. Chairman, to submit a statement for the record immediately following to define the process followed by Artais, Inc., of Columbus, Ohio, since the inception of its product in 1975. I think you will join with me in asking the FAA and others concerned about safety in our Nation's skies as to why they are not using this system.

Allow me just to take another moment if I may, Mr. Chairman.

Mr. Oberstar. Without objection, the document referred to by the gentleman will be included in the hearing record.

Mr. McEwen. Thank you, Mr. Chairman.

Let me just give you a brief background, if I may. In early 1978 this company began a six-month operational test of the Weather-CheckR system at Don Scott Airport in Columbus. These tests clearly showed that the Weather-CheckR was accurate and consistent. Subsequently, four FAA representatives, after a stormy House committee session on the subject, arrived at Don Scott to observe the system.

They stated that it incorporated all technology that they sought to develop and to implement. Thereafter, Artais was requested to assist the FAA in preparing the standards for automatic weather observation.

In the summer of 1978 Artais made disclosures to the FAA on its technology, since its patent application was already pending. This work resulted in Advisory Circular 9154 issued by the FAA in October of 1978.

On July 31, 1979, the United States Patent Office issued the patent. On August 12, 1979, FAA Administrator Bond approved the Weather-CheckR system for use under FAA instrument flight rules for Part 91 operations.

In December of 1980 the research and development branch of the FAA notified the flight standards branch that the system was technically qualified.

In September of 1983 the National Weather Service issued a contract to Artais for production of two prototype systems. Five days later, the Lynchburg unit was installed at Lynchburg Airport in

Virginia. In October of 1983 the National Weather Service began monitoring and evaluating the unit. On August 20, 1984, the unit was approved for scheduled airliners by the National Weather Service. In November of 1984 the Artais Lynchburg unit was commissioned by the National Weather Service and the FAA.

Now, once again, throughout this process FAA personnel have visited and studied this equipment and its operational ability. Despite the cooperation of Artais, the FAA has consistently refused to enter into contracts for supplying additional equipment.

Incredibly, during this period, FAA funded development of a duplicate system with another company and continues to refuse to procure off-the-shelf available units to proceed with procurement. The company selected to redesign the system and produce a limited number of prototypes has been unable to reinvent the equipment that is currently available.

Mr. Chairman, I think it's important during the course of these hearings that this information be continually addressed, and the fact of the matter is that this situation we hope to correct can be corrected at any time that the FAA chooses to do so.

I thank the Chairman.

[The material referred to by Mr. McEwen follows:]

MEMORANDUM

In 1975 and 1976 Roberto Arpino of Artais, Inc. spending the company's own money without any government development contracts, conceived and developed an automatic weather system known as Weather-CheckR. In early 1977, the aviation industry trade association wrote to the Secretaries of Transportation, Commerce and Defense urging them to speed the development of an automatic weather reporting system in the interest of aviation safety.

In early 1978 Artais began a six month operational test of the Weather-CheckR system at Don Scott Airport, Columbus, Ohio. These tests clearly showed that Weather-CheckR was accurate and consistent. Subsequently, four FAA representatives, after a stormy House Committee session on the subject, arrived at Don Scott Airport to observe the system. They stated that the system incorporated all technology which they sought to develop and implement.

Thereafter, Artais was requested to assist the FAA in preparing the standards for automatic weather observation. In the Summer of 1978, Artais made disclosures to the FAA on its technology since its patent application was already pending. This work resulted in Advisory Circular 91-54 issued by the FAA in October, 1978.

On July 31, 1979 the United States Patent Office issued patent #4163216 to Artais for the system covered by circular 91-54. It is an apparatus patent covering any weather parameter and gives patent protection for determining real time weather at an airport without human intervention.

On August 12, 1979 FAA Administrator Bond approved the Weather-CheckR system for use under FAA instrument flight rules for Part 91 operations. In December 1980 the Research and Development Branch of FAA notified Flight Standards Branch that the system was technically qualified. No further communication has been received by Artais relative to approval.

Octover 13, 1981 - the United States Patent Office issued letters patent #4295139 to Artais. This is a method patent for determining real time weather at an airport and communicating it to pilots without human intervention. In December, 1981 all branches of FAA submitted the Artais system for visibility to Administrator Helms recommending approval.

Also in December of 1981 Artais began to develop automated surface observation units for the National Weather Service. In February of 1982 Artais began development and production of a unit for Lynchburg, Virginia to be used for NWS approval for scheduled air liners. On August 6, 1982 NWS personnel from the Test and Evaluation Division, Sterling, Virginia began the NWS evaluation of the Artais Lynchburg unit.

August 10, 1982 - FAA Solicitation No. DTFA01-82-B27216 was issued for purchase of fifteen automatic weather reporting systems whose specifications read on patents owned by Artais. Such solicitation did not require off-the-shelf units but permitted persons to bid even though they had not developed or manufactured such a system. Each bidder was limited to bidding on 5 units. The solicitation did not advise the bidders of the Artais Patents although copies had been delivered to Procurement personnel preparing the solicitation.

Artais subsequently received notification from the FAA that IFB DTFA01-82-B-27216 for fifteen automated weather observation systems previously ordered had been cancelled. It is noteworthy that Artais had filed a protest involving Patent violations before this cancellation.

On February 23, 1983 Artais received FAA approval to report automatically on visibility and cloud heights for instrument landings by Part 91 and 135 operations. On June 3, 1983 Artais completed all shipments to the FAA for seven demonstration units ordered subsequent to the earlier FAA cancellation. FAA accepted all of those units.

On September 21, 1983 NWS issued its contract to Artais for production of 2 prototype systems. On September 26, 1983 the Artais Lynchburg unit was installed at Lynchburg Airport. In October of 1983, NWS began monitoring and evaluating the Lynchburg unit. On August 20, 1984 the Lynchburg unit was approved for scheduled air liners as AUTOB by NWS. In November 1984 the Artais Lynchburg unit was commissioned by NWS and FAA.

Throughout this process FAA personnel visited NWS facilities where Artais equipment is operational. In spite of the cooperation of Artais, the FAA has persistently refused to enter into contracts with Artais for supplying additional equipment. Incredibly during this period FAA funded development of a duplicate system with another company and continues to refuse to procure "off-the-shelf" available units to proceed with procurement. The company selected to redesign the system and produce a limited number of prototypes has thus far been unable to "reinvent" the equipment which Artais has on the shelf.

Now for the past year the National Oceanic and Atmospheric Administration has researched, discussed and written an RFP for real time weather sensing and communication devices. Bear in mind that Artais has systems operating in the field and patents reading on these devices. They have devices operating which were purchased by The National Weather Service, a division of The National Oceanic and Atmospheric Administration but the procurement of these systems continues to be delayed in the bureaucracy.

Subsequently, a jurisdictional battle developed between the FAA and NOAA and some say the Dept. of Defense as well.

At first, it was learned that NOAA had won the battle, now, though accurate information on these byzantine battles is difficult for the private sector to get (much less understand), there seems to be a question again since both agencies are continuing their ponderous pace toward, we assume, ultimately making the state of the "real-time" weather art available to the pilots and passengers of the nation"s air lines.

Now NOAA apparently will fall into the FAA trap and once again two or three new companies will be asked to design equipment which Artais has already designed and patented. This of course, will further delay receipt of the benefits of this technology by the nation's pilots and passengers.

ARTAIS WEATHER AUTOMATICALLY REPORTED ENROUTE

The Artais Systems for automatically observing and disseminating weather, without human intervention, are intended for use by pilots in all phases of flight. They provide the very latest weather for use before takeoff, enroute and during approach and landing.

In addition to the reporting of standard automated weather parameters, including ceiling and visibility, the system is now capable of reporting the location of thunderstorms within 120 miles of the automated station. This information may be reported by voice directly to airborne pilots and via voice or digital signals to all other interested parties.

Thunderstorm information will be given to the pilot relative to a nearby navigation aid. Using the bearing and distance of the storm from the station will allow the pilot to easily plot the storm location on his radio navigation chart. Storm location relative to the navigation aid, rather than relative to the thunderstorm sensor, is computed by the ARTAIS weather processor. The storm location will normally be described relative to the navigation station which is broadcasting the voice weather message. If more than one station is broadcasting the message, each station will report the thunderstorm in terms of its location.

One Artais System would send the weather and thunderstorm message to each VOR or other navigation aid in the relevant area and describe the location of each thunderstorm for each station differently. The same weather and thunderstorm message would also be directly communicated to the FSS's chosen to receive the message both verbally and over a printer as desired. These weather messages would be updated by the ARTAIS computer once each minute.

In this way the FSS personnel would know at all times the exact message carried over each VOR, and therefore, the most current weather in their area. The FSS personnel would always be aware of any hazardous weather moving through the region for which they are responsible. FSS personnel could, of course, interrupt the automatic weather information at any time to broadcast over the navigation aid. They would also have the capability record a message in the ARTAIS system which would be automatically transmitted after the weather message.

Mr. **Oberstar**. The gentleman will have ample opportunity, as will members of the committee, to raise those questions with the FAA and with other authorities that will be testifying at our hearing today.

The gentleman from Georgia, Mr. Rowland?

Mr. **Rowland**. No statement, Mr. Chairman.

Mr. **Oberstar**. We welcome to our hearing a familiar figure before this subcommittee and others on safety issues generally, but specifically on aviation safety, Mr. Burnett, Chairman of the National Transportation Safety Board.

Would you identify your associate?

Mr. **Burnett**. Mr. Laynor, who is the Deputy Director of the Bureau of Technology.

Mr. **Oberstar**. Would you both rise? Raise your right hand. Do you solemnly swear that the testimony you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. **Burnett**. I do.

Mr. **Laynor**. I do.

Mr. **Oberstar**. Thank you. I want to compliment, as I have done before—I guess it's becoming a familiar refrain, but it's one that bears repeating—the NTSB and its Chairman for the vigilant watchdog role played over years, continuing to be played now in such a responsible way over safety, particularly over aviation safety. We are indebted to you for your vigilance and for your courage in speaking out on difficult issues when it would be easier not to.

TESTIMONY OF JIM BURNETT, CHAIRMAN, NATIONAL TRANSPORTATION SAFETY BOARD, ACCOMPANIED BY WILLIAM LAYNOR, DEPUTY DIRECTOR, BUREAU OF TECHNOLOGY

Mr. **Burnett**. Thank you, Mr. Chairman. Members of the committee, I am pleased once again for the opportunity to appear before you to discuss hazardous weather and aviation safety. Your continued interest and vigilance in these issues are commended.

Accident data analyzed by the Safety Board for 1980 to 1986 show that weather conditions associated with thunderstorms and convective activity were cited five hundred forty-five times in accidents involving U.S. civil aircraft. Many hazards of the conditions include hail, lightning, tornadoes, turbulence, and heavy rain.

Although lightning strikes have been cited as a cause or factor in accidents only twice during this seven-year period, lightning strikes may become a more frequent and dangerous threat to the new generation of aircraft containing composite materials, glass cockpits, and fly-by-wire technology.

The most significant hazards to aviation are thunderstorms and low-altitude wind shear, which have resulted in over six hundred fatalities since 1973. In fact, the 1980 to 1986 air carrier and general aviation accident data indicate that thunderstorms and wind shear were cited sixty-eight percent of the time. The most important facet of this problem involves the detection and rapid dissemination of severe weather information to pilots.

Following the thunderstorm-related crash of a Southern Airways DC-9 at New Hope, Georgia, on April 4, 1977, the Safety Board recommended that the FAA develop an aviation weather detection system for both en route and terminal areas capable of displaying multiple-weather echo intensities. We also recommended that this information be transmitted to pilots via the controller as a safety advisory or via an electronic data link.

We again made a similar recommendation following the thunderstorm accident involving an Air Wisconsin Swearingen commuter aircraft near Valley, Nebraska, that occurred on June 12, 1980.

These recommendations are in an "open—acceptable action" status, as the FAA continues the development of Doppler radar to provide this capability.

Also following the Southern Airways accident, we recommended that the FAA formulate procedures for the timely dissemination by air traffic controllers of severe-weather information to flight crews. In response to this recommendation, the FAA and the National Weather Service established the center weather service unit in the air route traffic control centers.

Following the Pan American accident at Kenner, Louisiana, on July 9, 1982, the Safety Board issued fourteen recommendations to the FAA. These recommendations concerned the subject of information regarding hazardous meteorological conditions. Many of the recommendations dealt with improvements to the current low-level wind shear alert system in the use, display, and processing of the data and the location of the wind sensors. All of these recommendations were accepted by the FAA.

Three years later, another tragic wind shear accident occurred, involving an L1011 aircraft at Dallas-Fort Worth International Airport on August 2, 1985. The accident claimed the lives of one hundred thirty-four passengers and crew members. One person on the ground was killed.

Following the accident, the Safety Board issued seventeen additional safety recommendations to the FAA and to the National Oceanic and Atmospheric Administration and the National Weather Service. The recommendations were intended to correct identified deficiencies in the area of operational procedures, training, air traffic control, and weather instrumentation and dissemination. About three-quarters of the responses that we have received and evaluated have been favorable to these recommendations.

Although the FAA has been involved actively in trying to reduce the low-altitude wind shear hazard since 1967, it was only recently that the FAA embarked on developing a systematic approach to the wind shear problem.

The FAA's integrated wind shear program plan is based on information and assistance provided by the Safety Board and others in both Government and industry. It is composed of the following program elements: education, training, and operational procedures; ground sensors for the detection of low-altitude wind shear; airborne sensors and flight guidance systems; terminal information systems; and low-level meteorological hazard characterization.

The education, training, and operational procedures element of the program, consisting of wind shear training aid documents and videos, has been released to the industry. The training aid is designed to present an effective means of educating and training flight crews to recognize and avoid the wind shear threat.

The development of the training aid and videos was undertaken by the FAA and a consortium of aviation specialists from the Boeing Company, United Airlines, McDonnell Douglas, Lockheed of California, Aviation Weather Associates, and Helliwell, Inc.

Although we are aware of the FAA's position regarding the use of the current reflective weather radar systems by tower controllers, we believe that there are benefits which could result in the use of such radar systems without significantly affecting the controller's workload. However, we do not intend to imply that current radar systems should be a substitute for or should delay the implementation of terminal Doppler weather radar, which shows the greatest promise for effective detection.

Until the various technological black-box advances are available, pilots, their judgments and actions, will remain a key prevention tool in avoiding weather-related accidents. We must enhance the low-level wind shear alert system and provide the enhanced information to pilots in a flight crew-usable, timely format.

We must stress the importance of making and disseminating pilot reports in a timely manner to terminal air traffic control facilities for prompt dissemination to flight crews. We might heighten the awareness of pilots to the hazards of thunderstorms and convective activity. We must train pilots in escape techniques from inadvertent wind shear encounters.

We must equip center weather service units with state-of-the-science equipment with which to perform their function. We must streamline the dissemination of National Weather Service-generated data to air traffic control facilities and flight crews.

Finally, we must stress the avoidance by pilots of any thunderstorm or convective phenomena which may be a potential threat to aircraft safety.

All of these things must be accomplished in the short term to prevent the continued occurrence of accidents related to thunderstorms and convective activities.

Mr. Chairman, that completes my testimony. I would be pleased to respond to your questions.

Mr. OBERSTAR. Thank you very much, Mr. Burnett. We greatly appreciate your survey of the history and the recommendations.

I look back to 1977, the recommendations by the Board following the Southern Airways crash, referring to en route centers, TCA's, data link, the relationship of the controller to the pilot. I go back to 1982, Kenner, Louisiana, six recommendations relating again to observation, operational limitations, R&D, training, flight instrumentation, dissemination. And two years, Dallas-Fort Worth, seventeen recommendations.

What has the FAA done in response to your recommendations? You have touched a little bit on a few of the things. But this goes back over a number of years, a decade and a half.

Mr. BURNETT. I think, in fact, Mr. Chairman, we made our first recommendations concerning, for instance, the development of the Doppler radar back in 1973 or 1974, following the 1973 accident. Of course, it has been that system that has been the key to the vision that the Safety Board has had for protecting aviation from the dangers of thunderstorms and particularly the wind shear problems.

The FAA has been involved in the development of those systems. We are now reaching the threshold, perhaps, of having those implemented in a way that will begin to fundamentally improve the safety of the traveling public. But it is a tree that has been planted and has not yet borne fruit, although we have to recognize the accomplishment in getting it to the point that it is today.

In addition, after the recognition of the microburst phenomenon as a key problem as far as the potentially fatal wind shear type accidents are concerned, the Safety Board made recommendations to the FAA for the development of training programs which they have now implemented. I think this is very promising for some immediate effect upon this summer's safety and certainly that of the years to come.

I don't think that the FAA has gone as far as the Safety Board would like them to do in incorporating that knowledge that they have developed in the regulatory program to be certain that the air carriers will incorporate those processes and attitudes that have been developed into operational procedures and into training programs as a matter of regulatory mandate.

Mr. OBERSTAR. I am trying to get at whether you found the FAA willing, cooperative, responsive, or have they instead put up a defense mechanism to each of the recommendations made.

Mr. BURNETT. Well, I think more than in some of the areas that we discussed with the FAA they have been cooperative in this area. They have, especially for time periods within this fifteen-year period we're talking about, sometimes been slower than we would have wished them to be.

I think in recent years they have been moving forward as quickly as the technological situation would permit them, although I don't think that's true for the whole fourteen-or-fifteen-year period.

Mr. OBERSTAR. In your review—by that, I mean the Safety Board's review—of the transportation sector accidents, the whole gamut over which you have jurisdiction, has the Board found any mode of transportation more vulnerable or as vulnerable to weather as aviation?

Mr. BURNETT. Well, weather is a factor in almost all types of transportation accidents across the board. I don't think we'd find any area in which you have the dramatic weather-related situation that we have in general in aviation, for general aviation accidents as well as air carrier accidents, as we have testified, is one of the prime factors. Although weather is a significant factor across the board, it probably is more so in aviation.

Mr. OBERSTAR. One of the concerns the Board has expressed over a period of time on other review of FAA is the workload of the air traffic controller, the excessive overtime, the excessive time spent at controls, the lack of sufficient numbers of FPL's.

In connection with weather, it appears that the thrust of FAA efforts is to add yet another responsibility onto the controller's workload: disseminating weather information. Perhaps the state of the art of technology is such that that may be the only efficient, at the present time, way to do it or the only means, technologically feasible means of doing it, although the Board has recommended a data link as far back as 1977, maybe even earlier.

Do you have a concern about the role of the controller in this area of weather information dissemination, considering that a controller may have as many as twenty-eight aircraft on his or her screen at any one time, vectoring those aircraft and talking to all of them, giving them vital information about separation, and then also being required to pass information on about weather? Do you have a concern about that?

Mr. BURNETT. Well, that certainly is a matter of concern. The FAA's doctrine is, and I think quite appropriately so, that the first obligation of the controller should be to provide separation of traffic. That is why it is very desirable that we develop—and this of course is over the long term—an electronic data link so that real-time weather information can be provided to pilots without passing through the controllers and without adding to their workload.

In the meantime, however, that is about the only way we have of transmitting this ground-generated, at least, information to the aircraft cockpits, and I don't think we can turn our back away from that opportunity when we have information of hazardous conditions that can only be transmitted in that way and we have the obligation to try to develop procedures that will allow that to be done consistent with the other obligations of air traffic control.

I think the FAA has been very conservative in protecting the controllers in that regard and not instituting procedures that would burden them. So I don't think they can be criticized from that side of the equation. The Safety Board has suggested in some cases that they needed to go a little further in developing procedures for the transmission of information.

And we have certainly suggested that they be given more help in the way of training for their own weather coordinators and for weather personnel, not only in the en route centers where they have been provided, but also in the major terminal areas, so that they would have people who would be able to interpret developing weather information and give them scientifically correct information that they can pass on.

We have also encouraged the development of the pilot reporting system. Many times other pilots are the first ones to experience the wind shear situation, for instance, and unless we get that information into the hands of the controllers so they can pass it along, it will not be provided to the people that it could protect.

Mr. OBERSTAR. Well, yes, but I am sure that you are aware that under the FAA's NAS Plan, the agency is not intending to provide data link for several more years. Meanwhile, the controllers are going to have to make do. They don't have it in their plan to move faster. Is that justifiable under the current state of the art of technology? Could that be moved ahead? What is your reaction, your commentary on the NAS Plan that says we won't have datalink for several years?

Mr. BURNETT. I will let Mr. Laynor respond.

Mr. OBERSTAR. Thank you.

Mr. LAYNOR. Well, the data link is going to depend on equipping the aircraft with the discrete addressing beacon transponder systems. Of course, that is now pending regulation requirement in the future. There is a lot of allocation. That system, the data link, is going to have a lot of uses, weather being one of them, flight planning be another. So there are still a lot of technical problems to be worked out there. I think they are moving forward in the data link, but it will be a long time before it is totally implemented throughout the fleet.

But the FAA has taken other actions to partially address the problem.

Mr. **Oberstar**. You don't think that there is a policy problem, that as a matter of policy that they're dragging their feet? Or is it that the plan is technology-dependent, is that your feeling?

Mr. **Laynor**. Well, there are a number of people who are still working on the technical aspects of the implementation of the Mode S system, Lincoln Lab being one. There is a lot of data formatting, standardization, of course plain hardware development and equipping the aircraft with hardware is all part of the equation. That is taking place. The airlines, through AIRINC, have implemented in some cases their own data links, and they are very effective in transmitting the information to the air carrier aircraft.

The FAA has taken other actions, one of them being the hazardous inflight weather advisory service, to take some of the burden off the air traffic control center controllers. I think that has presently been implemented in three centers. We had some concerns at one point in time that the pilots were not being educated properly to achieve the optimum use of the service, but the FAA has responded somewhat to that.

So the en route area is the HIWAS, the implementation of flow control for convective weather, predicting convective weather circumstances, are all partially effective.

Mr. **Oberstar**. Thank you.

One final question before I pass on to other Members. You cited lightning strikes as a causal factor in accidents as being infrequent. But is there any technology being developed to provide detection of lightning strikes or for the onset of lightning? If so, what can be done? Once it's detected, what can you do about it?

Mr. **Laynor**. Well, it's a two-sided equation. There are systems to detect lightning. The detection of lightning, of course, is a real-time situation, and it's basically for the purpose of helping you detect where convective weather is. There is a lot more action being taken by the manufacturers, and particularly for the new fly-by-wire aircraft and the new composite materials being used to protect the aircraft against inflight lightning strikes. That certainly is a concern with new airplanes.

Mr. **Oberstar**. Is there any technology under research now for detection of lightning that you are aware of?

Mr. **Laynor**. Well, I am aware of technical systems which are available today for the detection of lightning. That is already available. It's one element which could be put into the total information system for the weather ground-base to detect heavy rainshowers and lightning. It gives you a very good indication that there is considerable convective activity and the possibility of wind shear.

Mr. **Oberstar**. Yes. I note your reference to the new composites that are used in aircraft manufacture today, and their sensitivity, perhaps, or greater sensitivity to lightning strike. Is there any study done on what could happen to those materials in case of a lightning strike?

Mr. LAYNOR. I understand that one of your witnesses later on will be Mr. Kirchner from the Boeing Company.

Mr. OBERSTAR. Yes.

Mr. LAYNOR. I am sure the Boeing Company has been doing an awful lot of work during the past decade on that problem.

Mr. OBERSTAR. And you have not?

Mr. LAYNOR. We have not, no, sir.

Mr. OBERSTAR. Thank you very much.

The Chair recognizes the gentleman from Pennsylvania.

Mr. CLINGER. Thank you very much, Mr. Chairman.

Mr. Burnett, you have talked a little bit about some of the recommendations that NTSB has made to FAA with regard to facilitating the real-time adverse-weather communications to the cockpit from the controller. To what extent have your recommendations been implemented to date? Can you give us some idea of that?

Mr. BURNETT. Well, I think the general summary is that on most of our recommendations, not all, the FAA has been moving forward with them. Almost all of the recommendations that we have made in the wind shear area either involve research and development or are dependent upon research and development. Therefore, they are, unfortunately, relatively long-term steps. There have been a few we have made that have been fairly easy to accomplish, and the FAA has generally done those.

But the projects that they have ongoing for the most part have not yet borne the fruit that is expected of them at some point in the future. That is not say that we have not made some progress in the area of dealing with, particularly, wind shear in the last few years. We have. But the progress that is yet to come from the work that has been in progress is yet to be fully realized.

Mr. CLINGER. With regard to the controllers, has the medium for advising pilots of threatening weather conditions, what kind of training does the controller receive as far as weather reporting, understanding the weather conditions and so forth?

Mr. BURNETT. Well, not a lot.

Mr. CLINGER. Does he need more, I guess is my question?

Mr. BURNETT. Yes, they do need more. In fact, one of the recommendations that we made to the FAA that they have not adopted is that the weather coordinators in the facilities—they have a training course at their training center, I believe, in Oklahoma City, which is for the weather coordinators. Yet, many of the weather coordinators never receive that training. We have recommended that they consistently be provided it, and the FAA has not found it necessary to do so. So that is one of the bones of contention between us and the FAA.

We have made recommendations to them for some training in the facility for controllers about the problems of microburst so they will have a better understanding. And they have, in response to that done some briefings within the facilities on the matter. I think that has improved the ability of the controllers to handle and understand the situation that they're dealing with.

Do you have anything to add to that?

Mr. CLINGER. Just so I understand it, within a center there would be a weather coordinator who then relays information to a controller, who would then relay it to a pilot? Is that the progression?

Mr. BURNETT. That's correct. But the FAA is very limited in what they allow the weather coordinators to do. They don't attempt to let them do any meteorological functions, and that's the reason we have—in response to Safety Board recommendations in the en route centers—they have center weather coordinators that are meteorological personnel.

One of the problems we saw in the situation leading up to the Delta 191 accident in Dallas-Fort Worth was the fact that that facility, that activity, is manned at such a low level that when the center weather service personnel there decided to go to lunch, I recall, it was left unmanned, and this whole convective activity developed during that interim.

Mr. CLINGER. And nobody else was aware of this development?

Mr. BURNETT. In each case, the people who could have been aware of it were out to lunch. And not to criticize the people there because they had no other—they did not have any backup, and of course a person has to have breaks and has to eat lunch. So it's not a problem with the personnel, but it was certainly a very marginal manning situation.

The Safety Board after that accident made an additional recommendation to the FAA—I'm not sure whether I have already testified to this—that they put weather personnel in the major terminals. They have also refused to do that.

Mr. CLINGER. Do you see any necessity for training the controllers themselves, in weather and weather-related data? That is what I am getting at. Isn't there a time delay? You have a progression from the weather coordinator to the controller to the cockpit; is there a delay involved there that we could do away with if the information went directly from the controller?

Mr. LAYNOR. Well, certainly there is. But part of the problem in the centers and also in the terminal area right now is that the controllers do not have the tools to observe the weather right at their work stations. That is part of the plan also, is to implement radar systems both en route and in the terminal area, which would provide the controllers with a little bit better idea of both the level of the weather, the intensity of the weather, and the location.

Right now, the controllers depend on the center weather service units in the center to give the forewarning of weather conditions that are coming and that are going to affect their airspace. Then they also depend on pilot reports, and they do pass this along.

But they don't have the tools right at their station to be very effective in the dynamics.

Mr. CLINGER. Thank you.

Mr. BURNETT. I don't think we want to try to make meteorologists out of controllers. They don't have the time to do that or to do any kind of sophisticated analysis. I think part of what we're trying to do—for instance, one of the problems with the Doppler radar is to develop the software to give the information in a way that it does not require a meteorologist in the facility in order to be able to know what it means so it can be transmitted in a way that is meaningful to pilots without having to have controllers that are sophisticated in that area.

They do, of course, need to have a sense of how weather impacts the aviation environment in order to be able to provide good control services. But we don't need to carry that too far.

Mr. **Clinger**. I just have one other question, Mr. Chairman.

The LLWAS is generally considered to have an unacceptably high false-alarm rate, as I understand it, and that has resulted in lessening of confidence of pilots in the system itself. I am wondering if, as a result of your investigations in to any weather-related accidents, you ever encountered a situation where a pilot apparently received an LLWAS-based advisory but knowingly flew into an actual wind shear situation?

Mr. **Burnett**. Well, yes, we have, although I think, in fairness to the pilots, we have to understand that this information is transmitted to them in a way that is not very useful to them. I mean, it's just not something that the pilots can digest and make a determination of what it means to them in the time that is allotted there. That is one of the severe problems with LLWAS.

And we have made recommendations to the FAA doing something about that, and they have responded to us that they are going to.

Mr. Laynor might enlighten you further as to exactly the status of that.

Mr. **Laynor**. Well, Dr. McCarthy, when he comes up, I am sure will have something to say about that.

But there are a lot of activities within the FAA, a lot of them being centered around the National Center for Atmospheric Research, to enhance the low-level wind shear alert system with additional sensors and with different types of software algorithms to provide a more effective warning statement to the pilot.

Some of that activity is being tested this summer out in Denver, and we are watching that very closely. It's very encouraging.

Mr. **Clinger**. Thank you, Mr. Chairman.

Mr. **Oberstar**. Thank you, Mr. Clinger.

Following up on the point that the gentleman from Pennsylvania just raised, during the weather-related investigations that NTSB has conducted over a period of years, one of the recurring themes is a mindset among pilots, and one that probably derives from company orders or policy, is to try to get in and land as quickly as possible.

Do you detect a change in that attitude since Dallas?

Mr. **Burnett**. Well, I think both Kenner and Dallas have been very dramatic indicators to the aviation community about the dangers of wind shear and, I think, have contributed to programs that have educated pilots as well as management about the hazards involved.

I think one of the problems is that wind shear is something that has been with us for a long time and pilots experience it frequently in a rather benign way. The recognition of the microburst and the problems that it presents for aviation is something that has taken place fairly recently, and it unfortunately has almost taken these accidents for the aviation community to really begin to appreciate that there are some forms of wind shear through which you must not fly and cannot fly. I think that was the message that is now fairly well out.

In fact, I think we documented it in the United Airlines incident in Denver, which was an accident because it damaged the aircraft. The training that the pilot had received in that situation enabled him to recover from the situation. Unfortunately, we did not have a system in place that effectively kept him from getting in it in the first place, and I don't think we want to have to rely on pilot performance in getting out of a wind shear because that is too problematical a situation.

Mr. OBERSTAR. Well, I recall testimony at our hearing in 1985 in which a pilot said in a career spanning thirty years you might experience microburst once.

Mr. BURNETT. Well, I am sure everyone, if they realized the hazards of microburst, hopes that they will not once. Otherwise, once is too many, I think.

Mr. OBERSTAR. Yes. That was his point.

Mr. BURNETT. You would hope that you would get through it then, but actually, the microburst, as I understand from the people like Dr. McCarthy, is not an infrequent occurrence. It occurs very frequently. The fact is that it only works to our dramatic disbenefit when you happen to have an airplane flying through one at fairly low altitudes.

Mr. OBERSTAR. That's the problem.

Mr. BURNETT. Fortunately, that coincidence of situations does not happen more often than it does, but when it does it is a very severe problem.

Mr. OBERSTAR. Correct.

The gentleman from Georgia, Mr. Rowland?

Mr. ROWLAND. Thank you, Mr. Chairman.

I want to follow up on the question that you and Mr. Clinger were asking regarding transmission of data. It seems that the controllers have a full plate already trying to keep aircraft separated, and can't give full attention to this problem. And in fact, they are not meteorologists anyway, as you indicated.

And the loss of time in transmitting data from the detection device through the controller and to the aircraft seems to be very important also.

I believe you mentioned that there were three centers where the controllers were being bypassed and the information was going directly to the aircraft. Can you tell me exactly how that is done?

Mr. LAYNOR. Well, that is the hazardous inflight weather advisory service, and it is not the dynamic sense. it's the fact that when there is severe weather in an area, it is broadcast on a VHF frequency, the flightcrews have to tune in that frequency when they enter the center's airspace, and without inquiring from the controllers or initiating any communication on their own, they're provided a weather report for the center's airspace they're entering.

It works very much the same as the automatic terminal information service has worked for years in the terminal area. When the flightcrew is coming into the terminal area, they tune in a discrete frequency and they receive the weather information, the active runway approaches in progress.

Mr. **Rowland**. So this is not specific information about microburst then?

Mr. **Laynor**. It's not specific—it may include information that the conditions are conducive to microburst. But a microburst is a very short-lived phenomenon, very dynamic. It spawns very quickly and hits, it's hazardous for a few minutes, and then it dissipates. So it's not dynamic in the sense that it provides that kind of information.

I might also add, though, for en route high altitude and to a certain extent in the terminal area, one of the best sources for real-time information is the onboard weather radar aboard the aircraft, the airborne weather radar. One of the elements of this training program that you will hear more about later is certainly going to include better use of that equipment, more optimum use. There are a lot of people taking a look now to see how airborne weather radar could be used more effectively than the pilots realize that it can be used.

Mr. **Rowland**. In our present state of the art, can the onboard radar detect a microburst?

Mr. **Laynor**. The present state of the art, the onboard radar could detect the heavy rain associated with a microburst if indeed there is heavy rain associated with it. In most of the accidents we have investigated, aside from those which have occurred at Denver and Tucson, there have been heavy rains associated with the microburst.

Mr. **Rowland**. But there may not be heavy rains associated with it?

Mr. **Laynor**. That is very true.

Mr. **Rowland**. So we have still got to pursue the development of the terminal Doppler radar and some way to get the transmission rapidly to the aircraft. As I understand it, you just said it only take a few seconds. The way that the microburst is, is the wind comes down and hits the ground and then goes back up, and so you've got an updraft and a downdraft that are right next to each other. And the pilot in entering this area, if he's in an updraft, he tends to push the nose of the plane down and then within a fraction of a second he's in the downdraft and he's in the most vulnerable altitude, at a low flying speed. It really doesn't take that much wind to shove him into the ground, fifteen knots or twenty or thirty knots.

Mr. **Laynor**. Well, that is essentially true. It's like pointing a high-pressure air hose at the ground: it spreads out and it is the horizontal winds as well as the vertical winds that are significant and severe. The outflowing winds which change the effective airspeed that the airplane realizes flying through the condition is indeed a very significant factor in putting the aircraft outside of its performance envelope.

Mr. **Rowland**. I guess it's awfully hard to train a pilot. If you're going to encounter that maybe once in thirty years, how do you go about training pilots to be able to react to that situation?

Mr. **Laynor**. Well, it's been a problem insofar that the pilot's actions to counter this situation are not instinctive; they're not a natural reaction. Simulator training has probably gone a long way to demonstrating the kind of control forces you need to counter the effects of a microburst. The training programs, of course, are stressing avoidance as the key factor.

Mr. BURNETT. We think that the skills that the pilots have experienced in a simulator microburst condition are helpful, in order to encourage them to avoid the situation and understand how difficult it is to handle. But we have also documented—and the Denver situation was one—cases in which training that a pilot had received enabled him to avoid having a fatal accident after having gotten into the microburst situation.

Mr. ROWLAND. You say that if there is a series of conditions around an airport that would be conducive to developing microbursts, would you have some sort of criteria that aircraft would not try to land at that particular time if those conditions existed?

Mr. LAYNOR. Well, I think everybody has been struggling with that for a long time to try to come up with a balance of when you can say a microburst might be in the area and whether the pilot should terminate his operation or intentions to land. It's difficult to say. It is not like a crosswind situation where you can say I have fifteen knots or twenty-five knots of crosswind and that's beyond my airplane's capability.

Certainly, part of the advantage in the terminal Doppler radar will be to give a precursor of the downflowing air so that you have a little bit of a warning before it strikes the ground, and, hopefully, with enough training, if the pilots are told that there is a microburst spawning, they will know themselves that the situation is likely to be very dangerous.

Mr. BURNETT. One of the recommendations we made after the Dallas accident was that the FAA ask their principal operations inspectors to review the operating procedures of each of their airlines to ensure that there was an unambiguous, unequivocal message to pilots that they were not to land in a thunderstorm environment or when there was a thunderstorm in the immediate area of the terminal.

The FAA has replied to us that they wanted to get out their training package they were issuing, the educational package. And now our concern is, are they going to incorporate the thoughts that are in that into the actual operational procedures?

Mr. ROWLAND. I guess that high priority is on developing this terminal Doppler radar and being able to develop a transmission link to the pilot. That is the high priority?

Mr. BURNETT. For the longer range. There are other things that have to be done in the shorter range.

Mr. ROWLAND. Mr. Chairman, as a matter of interest, this past Friday we had a lot of thunderstorms in the area, and I was trying to leave National, and everybody was trying to leave from Dulles and Baltimore. We sat on the plane for two hours and forty-five minutes out on the tarmac waiting to take off. You know, none of the passengers complained.

Mr. BURNETT. Good. That's good news to us.

Mr. ROWLAND. Nobody wanted to take off. Everybody was laughing and just saying, "Well, this is something we've got to put up with." I got to Atlanta four hours late. But I wasn't disturbed at all; I got to Atlanta.

Mr. **Oberstar**. I wasn't disturbed either. I took Amtrak. [Laughter.]

Mr. **Rowland**. Thank you, Mr. Chairman.

Mr. **Oberstar**. The gentleman from New York, Mr. Molinari?

Mr. **Molinari**. Thank you, Mr. Chairman.

I have a couple of questions on the subject. But before I do, Jim, since we have you here, there is one critical area that I would deviate from the topic to ask you about. You have taken a very, very cautious and red-flag view of the air traffic control system this summer and had given some very serious warnings to Members of Congress, the FAA, and everybody else about what we could expect this summer in terms of traveling and the hazards that are out there. But we are now in the summer. Could you give us a quick update on your feelings today as to where we're at?

Mr. **Burnett**. Well, since we began this discussion, the FAA has taken action to implement some new flow-control procedures that will protect the en route environment, or is designed to at least, or envisions, giving better protection for the controllers being overworked in the en route environment. That is involving, they say, some additional delays to aircraft.

They are attempting to do this in something that is in a dynamic fashion. I am not convinced that they are well prepared to do that dynamically, but the Safety Board is still in the process of trying to evaluate what they're doing and looking at the indicators to see what impact it has. And I think at this point we are not really able to give—at least I am not—an assessment of how effective that's been. But I think that they definitely are beginning to address the issue.

Mr. **Molinari**. Your fears are not allayed at this point?

Mr. **Burnett**. Well, no, I wouldn't want to go quite that far. I think I am encouraged that they are looking at it and that there has been some response to the concerns.

Mr. **Molinari**. Jim, some of us have had the experience of going to an air traffic facility and being present when there's a weather briefing given to the controllers and other personnel before they take the boards. Then, of course, go back a couple of years to the General Accounting Office questionnaire report, which indicated—I don't recall the figures—that a very, very high percentage of air traffic controllers do not transmit weather information to the pilots even when requested.

Now, I don't mean to suggest that they just flatly refuse because they don't want to give them the information, but because their primary duty is to maintain separation—that's what they're doing—they don't have the time. So what we find happening is that at the very time when that information is most needed, the information is not being given, and perhaps at other times when it really isn't needed, they have the ability and probably do transmit it.

So that leads me to this question. Would the addition of more air traffic controllers help that problem; that is, disseminating weather information to the pilots when needed?

Mr. **Burnett**. Well, I think if you reconstructed the system so as to create more positions and to use additional personnel to reduce the workload. The fact is that some of the times when they have the heaviest and most complex workload, they are fully staffed, and the addition of more personnel would just allow you to rotate your people more so that they would not manage to reduce the strain of it. In the long term, by creating more sectors, manned by more personnel, that in fact might be of some assistance.

Do you want to add to that?

Mr. LAYNOR. Well, part of the problem is only one person can talk to the airplane at one time, and it's more a communication space problem than people problem, I think, right now. We do believe our recommendations have addressed the need for perhaps more people in the tower and in the terminal facilities during the periods of convective weather. But these could be weather service personnel as well as controllers trained in meteorology.

Mr. MOLINARI. We do know that we have the phenomenon occurring throughout the country where some controllers are "two holing" it, handling more than one sector because of short staffing. I guess it's fair to say that in situations like that they are not going to be in a position to do other than maintain separation. So I would think that it's common sense.

Mr. BURNETT. Well, in situations in which they are understaffed—and there are situations like that—it would be better for them to be fully staffed, especially in the face of the kind of complex workload that develops when you have thunderstorm activity.

Mr. MOLINARI. Well, I think that goes without saying. But the question is would that permit more weather data to be transmitted to the pilots if you beefed up the areas where they are short staffed?

Mr. BURNETT. In some places at some times.

Mr. MOLINARI. The gentleman from Georgia raised the question about last week, last Friday night, when most of us tried to get out of Washington. The storm activity was obvious to everybody; the thunderstorm and lightning were there. A flight that left Washington National bound for Newark, the flight before I was supposed to leave, didn't get very far. It had to put down at Baltimore because of the storm activity. We found, in checking, that flights from all over the area were being diverted and landing at different airports. I couldn't help but think that since the weather systems were there—we saw it ourselves visually—why is it that all those planes weren't held in that situation? How can a plane leave National Airport and go such a short distance to Baltimore, for instance, and then learn that the weather is so bad that they've got to land only a few miles away? Shouldn't they have known that situation and just simply kept that plane on the ground as well?

Mr. LAYNOR. I believe that's a breakdown someplace, yes, sir.

Mr. MOLINARI. It is? Is this something that you witness frequently?

Mr. LAYNOR. Well, it's difficult to say. There are times when extremely dynamic conditions occur where there are aircraft airborne and flow control has not been effective in holding airplanes at their points of departure because of weather conditions en route or in the terminal area are just so dynamic that you can't predict them ahead of time.

Mr. MOLINARI. I understand.

Mr. LAYNOR. The aircraft then have to hold. The FAA tells us at least that one of their primary functions of their flow control, their central flow control facility, is to do the very thing that you're alluding to. If there is a lot of weather en route and it can be discerned and fairly accurately predicted, they hold airplanes so that they can meter the flow around that weather and still keep the rate coming into the terminal areas to a point where the terminal areas can accept it.

Mr. MOLINARI. Traditionally, when I see bad weather out there, I try to call up to see what's the situation from here to where I am flying, whether there are delays expected, and whether I should take the train. Invariably, I am told, "No, they're flying, there are no weather problems between here and there." And by the time I get to the airport, there's a forty-five-minute delay, which becomes an hour, and like last week, a couple of hours, two-and-a-half hours, and then, say, maybe four hours.

Do you have any information indicating that this is a deliberate attempt on the part of some of the carriers to ensure the maximum utilization of their planes? It just upsets me and galls me all the time that they have information that should be fed to the passengers so that passengers can have an option, where possible, of taking a train and getting home that night.

Do you have any information that there is some deception on the part of some of the carriers with respect to this type of practice?

Mr. BURNETT. No, we have no information except that what I think you have is observing what we see when we're traveling in the airports. There used to be a joke going around about the most commonly told lies in the United States, and I think one of them might be that, "You should have no problem making your connection, sir," other than just anecdotal observation, I wouldn't have anything to add.

Mr. MOLINARI. Thank you, Mr. Chairman.

Mr. OBERSTAR. The gentleman's time has expired. But I shared that concern from the other side of the attitude, "Let's get the aircraft in, land under all conditions." And the gentleman expressed a concern about taking off under all conditions. I think this is something we do need to pursue.

The gentleman from California, former Chairman of this subcommittee and now Chairman of the Aviation Subcommittee, Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman.

Mr. Burnett, Mr. Laynor, it's good to have you here.

Let me ask first of all with regard to that training you were referring to for pilots on wind shear and how to deal with it. Do you know whether or not that maybe gives the pilots some modicum of willingness to take on a wind shear, having gone through this training and maybe feeling that they can push their way through it?

Mr. BURNETT. Well, that has been one of the concerns with the training program.

Mr. MINETA. I am sorry, could you get the microphone up closer?

Mr. BURNETT. Yes, certainly.

That somehow it would encourage pilots to think that they could tackle the wind shear or the microburst. My feeling is that if it's properly accomplished, it will have the opposite result.

I think one of the problems, perceptual problems that we're dealing with out there is that some pilots have attempted or have had the tendency to equate the microburst with the more benign forms of wind shear, and therefore have thought, "Well, I've flown through wind shear before." I think the fact that they experience in the simulators the severity of it, even if they are one of those who are successful in getting through it, and I think there are some that cannot be gotten through.

One of the problems with our previous simulator programs is that some of the tests that they were challenged with perhaps were too easy. So that one of the objects of the new training program is to be sure that it stresses avoidance as the first line of defense and successful transition of the wind shear as merely the last line of defense if for some reason, through failure of information systems or lack of judgment, one has gotten into that situation.

Mr. MINETA. With respect to terminal Doppler weather radar, the FAA proposed $130 million for the installation of the terminal Doppler weather radar at twenty-four sites sometime in late 1988, fiscal year 1988.

Now, it's my understanding that the Appropriations Subcommittee on Transportation has now pushed that funding for the terminal Doppler weather radar from fiscal year 1988 into fiscal year 1989 in order to save $120 million.

Now, I suspect their thinking is that this program would be slipped into the early part of fiscal year 1989 and that that would not be that much time lost.

Do you have any comment on this budget choice by the Appropriations Committee and whether it will have any significant impact?

Mr. OBERSTAR. Would the gentleman yield at that point?

Mr. MINETA. Yes.

Mr. OBERSTAR. There is one additional point that the NTSB could respond to; that is, an additional piece of information that we have received that the subcommittee took that action on indication from FAA that they couldn't use that money in fiscal year 1988. If so, why not?

Mr. BURNETT. Mr. Laynor might be able to shed some light on that.

Mr. LAYNOR. Well, I think technology is probably driving that schedule right now. A very complex part of the terminal Doppler system is to be able to come up with the proper algorithms and software to do an automatic interpretation of what the radar is telling you and to put it into a format that the controller can use without interpretation. That is being developed today.

I think technology is driving it, rather than budget, right at the present time.

Mr. BURNETT. Well, I will say that the Safety Board's position has been that procurement of the hardware portion of the Doppler radar system should proceed. So that we would have that in place when we got the software ready and that the software could be prepared. I don't know whether Mr. Laynor has suggested we ought to back away from that position or not.

Mr. LAYNOR. No. I think we believe that the technical obstacles can be overcome. It's just a matter of time right now.

Mr. MINETA. What is the basic difference, then, between NEXRAD and terminal Doppler?

Mr. LAYNOR. Well, it's my understanding—I can't talk technically; perhaps Dr. McCarthy can provide a better technical answer to that—but the first, I believe, fourteen units of the NEXRAD, first NEXRAD procurements, will be reconfigured for installation in the terminal areas as both operational and test bed for the terminal Doppler program which will be implemented fully later.

The technology, the basic Doppler technologies, I think, are similar. There are different considerations in the way you use the radar.

Mr. MINETA. I believe that's at seventeen terminals.

Mr. LAYNOR. I have read both figures.

Mr. MINETA. Then you would suggest that by not moving ahead with the terminal Doppler weather radar, that we would be leaving a significant gap in our ability to deal with adverse weather detection?

Mr. LAYNOR. Yes, sir. I think the terminal Doppler is the only system that has the potential for giving the lead time that you need in the development of a microburst before it hits the ground and spreads out and becomes a real hazard. It's also the only system that is in the mill to take a look at the clear-air microburst problem such as occur out in Denver, because you no longer have the reflectivity signature and the other earmarks of a hazardous weather condition. A pilot can be fooled into a very hazardous situation without any prior knowledge.

Mr. MINETA. I may have missed it, and I would appreciate it if you could go over it for me. Are you satisfied now with whether or not weather information is being relayed in a timely basis to the flightdeck crew?

Mr. LAYNOR. Well, not totally, no. No. We are certainly not satisfied that we have struck the optimum way of transmitting weather from the National Weather Service.

Mr. MINETA. What is the shortcoming? Is it the kind of information that is being transmitted?

Mr. LAYNOR. Well, it's communications.

Mr. MINETA. Is it timeliness? What is it?

Mr. LAYNOR. It's communication. It's both the detection of dynamic weather conditions and being able to transit it through the loop from the people who have the tools to detect it, which in many cases is the National Weather Service, to the people who are talking to the pilots, to the pilots themselves. So it's a very difficult loop.

We have been very much concerned that you can sit on the ground and watch your television set and see the weather radars on your TV networks and get a better appreciation for the dynamic weather conditions than the pilots can.

Mr. MINETA. I take it part of the responsibility you put on the pilot, the pilot saying to the tower, maybe, about a microburst or when they land and saying that braking is poor to nil or fair to poor, whatever, rather than the tower sending a pickup truck out there to test the runway for ice and so forth?

Mr. LAYNOR. Well, sir, pilot reports are extremely important, and part of this training program addresses the need for accurate and timely pilot reports.

Mr. MINETA. What about in terms of the ATIS, do you find that that is being updated regularly enough, the ATIS?

Mr. BURNETT. Not always.

Mr. LAYNOR. In the course of our accident investigations, we find times when the latest information was not on the ATIS system. We have addressed that in the context of accident investigations, and generally we get the response that the FAA will take action and do something about that. But it is a problem.

Mr. MINETA. What do you do in a situation such as in Boston in 1982 when World Airways went in. As I recall there was a Learjet or something that had come in not too long before and had reported to the tower that braking conditions were poor to nil or something of that nature, but that information never was relayed from the tower to the next plane coming in; namely, World Airways. What about a situation of that nature?

Mr. BURNETT. We cited as one of the causes in that accident the failure of the weather dissemination system to provide available weather reports to the pilot of the accident aircraft, at least as a contributing factor. So it is certainly a matter of concern.

The other portion of it, I think, is that right now, a lot of that information is very subjective, and therefore its meaning to the pilot who receives it, even if they do receive it is——

Mr. MINETA. Is that information any better than going out and slamming the brakes on a pickup truck and then saying, "Oh, yeah, we've got a bad condition out here on the runway"?

Mr. BURNETT. Probably the experience of a similar aircraft—in other words, if you have a DC-9 landing and another DC-9 behind it—would be very helpful and be much more valid than a truck on the runway. But the fact is that there are some objective measuring systems available, and if we developed, as we have encouraged the FAA to do and they have done—and there has been a project by the FAA in association with NASA to look at how you would take some objective data and correlate it to aircraft performance in a way that would provide some objective help to the pilots.

Although the work, I understand, has been done, that system has not been issued by NASA. Therefore, we have got resources expended, but yet no impact in favor of aviation safety.

Mr. MINETA. Mr. Chairman, if I might ask one very quick question as it relates to general aviation?

We have far more fatalities occurring in general aviation because of weather difficulties. It seems to me that weather has been a factor in hundreds of general aviation fatalities, but my sense is that low-level wind shear is very rarely a factor in general aviation weather-related accidents.

What have you found to be the weather-related problems associated with general aviation accidents, and how would you characterize the DOT-FAA response to these problems?

Mr. BURNETT. Well, I think the prime weather-related problem in connection with general aviation accidents is pilot judgment, on the face of it. There is a growing problem with pilots being able to get good, timely weather information and have access, ready access within the terms of their schedule, to weather information. I think perhaps a temptation that will grow out of that is to proceed without it because of the difficulty in getting access to the flight service stations. Hopefully, when the FAA's automation program is fully in place there, that some of that will be alleviated.

But the problem has been moving to a new system and allowing the other one to atrophy before they get the new one fully in place.

Mr. MINETA. Have you found the new, let's say, automated flight service station information to be as good or better than the existing FSS?

Mr. BURNETT. The last time I think we addressed that problem formally was in connection with our air traffic control study I believe we did in 1982 or early 1983, in which basically the Safety Board has not been opposed to the automation process. Our concern has been that it was delayed in accomplishment, and in the meantime the integrity of the old system was being forfeited on the assumption that, "Hey, we're not going to put money and resources into this old system that we're abandoning." I have not gotten any satisfaction that that problem really has been alleviated at this point.

Mr. MINETA. Thank you very much, Mr. Burnett, Mr. Laynor.

Thank you, Mr. Chairman.

Mr. OBERSTAR. Thank you, Mr. Mineta. We appreciate it.

Mr. Burnett, is the low-level wind shear alert system the only wind shear ground detection system in operation today?

Mr. BURNETT. Yes, that's true.

Mr. OBERSTAR. The only operational system. Thank you.

The gentleman from Ohio.

Mr. MCEWEN. Thank you, Mr. Chairman.

If I could follow up on the question by the gentleman from California, I understand that you have no concerns then with an automated system that would give pilots immediate access to weather changes and information as opposed to this continual effort to have the conduit through the tower?

Mr. BURNETT. That we have no concern with it?

Mr. MCEWEN. That you have no problem with that philosophy.

Mr. BURNETT. Oh, certainly, we are supporting the development of a data link, an electronic data link and the collection and dissemination of real-time weather information directly into the cockpit as one of the objectives of good aviation weather systems.

Mr. MCEWEN. Good. And I notice in your testimony you make reference to the position of the NTSB in encouraging that back in April of 1977, now over a decade ago.

Mr. BURNETT. That's correct.

Mr. MCEWEN. And I take it you're not satisfied with the progress of the FAA so far?

Mr. BURNETT. Well, we would like to have seen that already in place. But I don't want to say that the fact that we don't have it is altogether the failure of the progress of the FAA. Some of it is in the technical development.

Mr. MCEWEN. Are you aware that there is a system that is available presently that can accomplish these tasks, Mr. Laynor?

Mr. LAYNOR. I am not familiar with the system that you were describing from Columbus, Ohio, Mr. McEwen, no, I am not.

Mr. MCEWEN. Mr. Chairman, I would ask permission to reinstate into the record the statement by John Sheehan, senior vice president, Government technical affairs division of the Aircraft Owners and Pilots Association, that he gave before our Subcommittee on Aviation in October of 1985. If I could just cite a couple of references that he made concerning the automated weather observation system that the FAA is pursuing.

In discussion of that at that time, he mentioned that systems that have support dial-up capabilities as well as voice are available and that implementation would cost about half of any new system that the FAA would attempt to design since examples are already in operation today. He emphasized each one of these three points by the statement, "I must say, we can ill afford to wait." He said, "Clearly, the FAA does not need to directly develop an AWOS system. We do not have to wait that long."

He then goes on to say, "It seems inexcusable that cost-effective solutions to many of the problems that our committee has discussed are not in use. The Federal Aviation Administration seems to be content to wait for the National Airspace System Plan weather programs and milestones, even though they mean service and safety improvements are being delayed in the system. We can wait no longer."

I would submit that a great deal of this problem could be resolved if the FAA were to use the systems available to it, as opposed to continuing a decade of discussion and reconsideration and failed new design efforts as the system continues to deteriorate.

Do you have any comments on that?

Mr. LAYNOR. Well, I think we're talking about two elements of the problem, the one being the availability of weather information for pilots planning a flight, and the ability to get a good weather briefing. There are a number of commercial systems of which I am aware that offer this service. The NBAA membership, of course, subscribed to a number of different weather sources. Most of the major carriers have their own meteorological departments, and they provide weather services. The general aviation user has to depend on services provided by the FAA and others.

I think that that is certainly one element of the problem. The element of the problem with regard to the encountering hazardous weather en route is the dynamic changes, and until we get a data link and proper tools nationwide to detect and transmit that information while the crews are en route, that will remain a problem.

Mr. MCEWEN. Well, let me submit that we have such hardware and such a capability, and every sixty seconds it's updated and it's directly available to the cockpit.

Mr. LAYNOR. I am not aware of it.

Mr. MCEWEN. It's being used presently by the Virginia system. The FAA is aware of it and continues to attempt to duplicate it, without much success. Its continued efforts to take a system that is presently available, to farm it out for redesign and retool—they've been unable to duplicate it in-house after these many years—are a source of frustration to those of us who recognize that it could be corrected immediately if they chose to do so.

I thank the Chairman.

Mr. OBERSTAR. I thank the gentleman from Ohio, and the Chair will review the documentation and testimony and include the pertinent parts of that, since it already appears in another hearing record.

[Excerpt from the statement of John J. Sheehan, Aircraft Owners and Pilots Association, October 30, 1985, Subcommittee on Aviation, of the Committee on Public Works and Transportation follows:]

EXCERPT FROM THE STATEMENT OF JOHN J. SHEEHAN, SENIOR VICE PRESIDENT, GOVERNMENT AND TECHNICAL AFFAIRS DIVISION, AIRCRAFT OWNERS AND PILOTS ASSOCIATION

* * * * * * *

It is regrettable that a tragic aircraft accident south as that, at Dallas-Fort Worth Airport was the catalyst necessary to bring the issue of accurate and timely weather information once again into the limelight. Unfortunately, that accident also had the effect of focusing attention too specifically on the threat posed by wind shear.

In the U.S., weather has been cited as a cause or primary factor in four of every ten fatal accidents and two of every ten nonfatal accidents in general aviation for a number of years. The aviation accident rate could be substaintially improved if accurate and timely weather information were more readily available for both preflight planning and inflight decisions. In addition to these safety considerations, weather is the single largest contributor to delays.

For that reason, I think that it is more important to focus on continued erosion of weather services for all aviation users and FAA's failure to embrace available new technologies as two of the most devastating deficiencies in the National Airspace System.

Erosion of service continues as the FAA, disregarding congressional guidance, reduces flight service station availability. Facilities for transcribed weather broadcasts (TWEB) and frequencies for en route flight advisory service (EFAS) are constrained, and the FAA R, E and D plan offers no hope for great improvement in weather information dissemination in the near term. The most critical element of the weather information system, the briefer/forecaster, has been forgotten in the mad rush to automation.

Amazingly, the FAA continues to ignore available commercial alternatives to National Airspace System Plan programs. Their determination to adhere to programs conceived in pre-1980 technology denies that the NAS Plan is the "living document" that airspace users have been promised.

Delays in bringing important weather detection systems on line are the product of unrealistic specifications which promise performance that manufacturers have yet to deliver in operational equipment. Huge sums of money have been and will continue to be invested in complex weather measuring and reporting systems which, if ever implemented, will arrive too late. Technology will have passed the wisdom of 1980 by!

This is particularly frustrating to the aviation community since many needs not being satisfied today could be if the FAA would turn to commercially available state-of-the-art solutions.

There are many examples of NAS Plan solutions to user and system requirements, the implementation of which is actually delaying service, or which will provide a less satisfactory alternative to one now available in the private sector. The near-term effect is that pilots are increasingly being denied adequate access to high quality weather information. This trend must be reversed. There are alternatives, and I believe that this committee's leadership can point the FAA and NWS in the direction of some of them.

Weather Radar

There is no doubt that advanced weather radar will improve airspace system safety. It will detect weather hazards such as wind and gust fronts, turbulence, mesocyclones, tornadoes, and icing conditions. I'd like to make two important points as I encourage you to press for accelerated NEXRAD implementation.

1. NEXRAD will not solve the terminal wind shear/microburst problem. Anthony Durham, Director of the NEXRAD Joint System Program Office, in his testimony, made it clear that the use of NEXRAD for terminal applications is years from being

reality. He implied that substantial research and development is still necessary and that significant technological hurdles remain.

As I am sure you are aware, the low level wind shear advisory system (LLWAS) has demonstrated its limitations. Enhancement will not permit it to satisfy the wind shear/microburst need. We should not let the FAAW commit "good money after bad" for additional research and enhancement on LLWAS.

The FAA suggests that off-the-shelf terminal doppler radars available today cannot meet FAA specifications for NEXRAD derivative terminal doppler weather radar (TDWR). True! But how many lives will be waiting for that complex solution cost? NEXRAD/TDWR isn't available today. Commercial alternatives are available that can detect wind shear in most scenarios and can begin providing that service in remarkably short time.

The FAA should select such a system. I believe that an ambitious program could put in place as many as 120 locations within seven months, for less than 10.5 million dollars.

2. NEXRAD availability has been described in previous testimony as being two to four years away. The FAA NEXRAD schedule implies an even more pessimistic 1991-1996 implementation. We cannot wait that long.

Certainly the delay suggested by the Office of Management and Budget is unacceptable. It is time to force aggressive action to make NEXRAD available.

One additional idea needs emphasis. NEXRAD is not terminal doppler radar! The issue is not NEXRAD verus TDWR. Each system meets a unique need and is necessary, but the terminal requirement can be met quickly, commercially, for very little money.

Flight service stations

AOPA's concern regarding FAA efforts to automate and consolidate flight service stations are well known. You have already heard testimony that Model I FSS enhancements, the first step in providing advanced technology to FSS specialists, have still not been "certified" by the FAA. Model II enhancements are years away.

Congressional concern about FAA plans to reduce the number of FSS sites led to guidance to the FAA (contained in United States Code 49 USCA 2224) which established the number of FSSs which could be closed and states that:

"After October 1, 1983, the Secretary may close additional FSSs but only if the service provided to airmen after the closure of such station with respect to information relating to temperature, dew point, barometric pressure, ceiling, visibility, wind direction, and velocity for areas served by such station is as good as or better than the service provided either by mechanical device or by contract with another party."

Despite that, the FAA continues to close facilities.

Such a closing was directed this month at the Pierre FSS in South Dakota. In this particular case, the promotion of two specialists reduced staff levels and forced the FAA to make the facility part-time (closed from 10:00 p.m. to 6:00 a.m.) effective 12 October 1985.

It is inconceivable that FAA mismanagement of personnel could result in the "closing" of one of only two full-time FSSs in that state. Clearly, the action violated the congressional mandate for "equal or better" service.

Earlier I suggested that the FAA determination to implement programs conceived in 1980 just because they are in the NAS Plan is a factor in delaying or denying state-of-the-art weather service. No other case illustrates that point better than the FSS modernization program.

The Model I weather displays amount to closed circuit television presentations of paper graphics to FSS specialists. Model II would provide digitized graphics, but only in monochrome. Keep in mind that Model II is still an FAA R&D effort and it is progressing at glacial speed.

Meanwhile, you or I can subscribe to any of several commerical weather dissemination programs and, using a personal computer, obtain high quality, high resolution, color weather graphics, at home.

Surely flight service equipment should be comparable!

In at least one of the FAA Regions, all of which sometimes seem to operate autonomously, a decision has been made to divert money intended for the Model I closed circuit TV to procure a leased weather graphics capability. Three FSS sites have already been selected. Imagine that—full color weather graphics capability for what FAA Headquarters planned to send for closed circuit TV! The Region should be commended for taking this very positive step in bypassing the long-stalled development of a truly automated system.

Wouldn't it be useful, though, if the FAA Headquarters could be convinced so that regional implementation could be expedited and standardized? Obviously, the national FSS automation program needs to be redirected. These weather graphics devices improve the quality of weather information available to the flight service specialists, expedite briefings, consequently improving the efficiency and safety of the system. They are here today. We can ill afford to wait.

Automated weather observation system [AWOS]

The FAA is planning a procurement of 571 AWOS through the year 1992 at a program cost of $216,000 per AWOS. Although they have/will receive FY86 budget approval for 126 systems, it is unlikely that any will be procured before early 1987.

Delays in the AWOS program will have a marked effect in several states on 1 January 1987, when certain instrument approach procedures will be cancelled because altimeter reporting is not available. California, Arkansas and Pennsylvania are among the states which will lose aviation service to some airports during marginal weather solely because AWOS is not in place.

The AWOS program is indicative of the FAA's tendency toward "gold-plated" systems. Implementation is being delayed because the manufacturer has so far been unable to produce a device that reports all of the FAA required phenomena. Disagreement between FAA and NWS regarding parameters and degree of system automation have further delayed the program.

Meanwhile, the FAA has circulated a draft Advisory Circular for public comment which provides guidance to manufacturers based upon which commercial AWOS would be eligible for airport improvement program funding. Our review of the draft AC finds that it places more stringent criteria on some elements of the commercial AWOS than exist for the government version. That is unfortunate since the higher standard tends to discourage entry into the market and drives the system cost up.

FAA's reluctance to abandon "government" AWOS is even more discouraging in light of the several commercial systems already available as supplements to manual observations. These systems support dial-up capabilities for computer and voice as well as air-ground voice. Implementation would cost about one-half of the projected cost of the FAA AWOS, and examples are in operation today. Again I must say, we can ill afford to wait.

FAA needs to continue R, E & D and certification of AWOS sensors and systems. A funding mechanism such as AIP must be maintained. The FAA should establish standards in cooperation with industry and permit the private sector to respond to marketplace demand.

Clearly, the FAA does not need to directly develop its own AWOS system. You don't want to wait that long.

Mr. OBERSTAR. Mr. Burnett, before I go on to Mr. Towns, from a pilot's perspective, what would constitute—just following up on the question Mr. McEwen asked—what would constitute usable hazardous-weather information?

Mr. LAYNOR. Well, usable hazardous-weather information is a real-time weather circumstance that's directly ahead of you that you are going to encounter within the next fifteen or twenty minutes.

Mr. OBERSTAR. One to four minutes could mean separate aircraft in the flight path.

Mr. BURNETT. It's a question not only of timeliness, but the information presented in a way that—within the time constraints that the pilot has that he can digest and use with the level of training that the pilot has. For instance—and this is not only in connection with weather but in the broad context, the glass cockpit—we are about to reach a level where the pilot is going to have all kinds of information available to him. The question is to get into a form that can be used quickly and to provide the kind of training that the pilot will be able to ignore that which is not relevant and be able to zero in what is relevant.

The problem now, one of the problems with the LLWAS system besides the fact that it's technically not well-designed to detect a microburst, is the fact that the information that is being transmitted is something that no one knows how to use. You'd have to have a computer in the cockpit and know how to make the calculations that would lead you to a conclusion that you didn't need to land. That has been difficult, and in fact has trapped some flightcrews already.

Mr. OBERSTAR. That's right. And it's the timeliness that is real-time information as the pilot is flying. Right now, he has to make go/no-go decisions, and availability of that information in a format that is readily understandable and readily usable right now by that pilot.

The gentleman from New York, Mr. Towns?

Mr. TOWNS. Thank you, Mr. Chairman.

Mr. Burnett, in reading your testimony, I can't quite determine whether the Board has conducted studies over the last several years as to whether the frequency with which weather is a factor in the accidents has increased or decreased. I am not sure. I want to make certain of that.

Mr. LAYNOR. Mr. Towns, it seems that every time we look into that, we come up with answers that are very close to the same as far as percentages of accidents that are related to weather. They remain about constant.

Mr. BURNETT. Since overall the accidents have gone down, you might say that we have made about as much progress in dealing with weather-related accidents as we have in dealing with other fields. But we have not made any more dramatic progress in that area.

Mr. TOWNS. In 1981 the former Board chairman testified before this committee, and he recommended that guidelines be established on the location and number of visibility markers necessary at airports, and he indicated that the Board had received a negative reply from FAA on this recommendation. Is airport visibility still a concern to the Board, or has this subject been adequately addressed?

Mr. LAYNOR. Well, yes, airport visibility is still a concern. We do have airports that have runway visual range transmitometers, measuring equipment. In those that don't, as were addressed in that recommendation where you require somebody to make a subjective judgment, they can see a marker, that is just not a real good system to provide real positive information or high-confidence information to the pilot. It remains a problem at some airports.

Mr. TOWNS. What, from the pilot's perspective, would constitute unseeable hazardous-weather information?

Mr. LAYNOR. I beg your pardon?

Mr. TOWNS. What, from a pilot's perspective would constitute unseeable hazardous-weather information?

Mr. LAYNOR. Unseeable?

Mr. TOWNS. Yes.

Mr. LAYNOR. Well, certainly wind shear is a hazardous weather that you cannot predict in the dynamic sense, and there is presently no equipment to detect it in front of the airplanes. You can have a warning that you are about to enter it—if that's what you mean.

Mr. TOWNS. That is exactly what I mean.

Mr. LAYNOR. Wind shear is certainly one of the biggest hazards.

Mr. Towns. Thank you very much, Mr. Chairman.

Mr. Laynor. Clear-air turbulence is another that I can think of.

Mr. Towns. I'm sorry?

Mr. Laynor. Clear-air turbulence is another hazard that the pilot can encounter without warning. There are systems being developed to help that.

Mr. Towns. Let me just ask a question that really I think my colleague from New York touched upon, and also my colleague from Georgia. You know, when you go out on the runway and you sit out there for hours and hours, isn't there some way that information could be gotten before people go out and sit on the runway for many, many hours before a decision is made?

Mr. Burnett. Well, that probably depends on the circumstances. In some cases, I guess all of us wonder whether or not before the plane was loaded and the gate was freed up, the next plane to come in, whether the airline knew that that was going to happen to us. But I am sure that there are other cases in which there are fast-developing weather situations or complex traffic management problems. And of course the airlines have to depend in many cases in that regard on the FAA to tell them, and we don't know when we're traveling at what time the airlines get notice of those problems.

Also, they do have very legitimate problems in trying to free up gates so that people who have just landed can come in and disembark also and that may be necessary to get the plane out even at the expense of staying on the runway so some other people can get off. So it's all a complex problem.

Mr. Towns. It sure is. And it's very frustrating if you happen to be out there.

Mr. Burnett. I know.

Mr. Towns. Thank you very much, Mr. Chairman.

Mr. Mineta. Would my colleague yield?

Mr. Towns. I would sure be delighted to yield.

Mr. Mineta. Let me ask one more question about mountain waves. Is there any way to detect mountain waves?

Mr. Laynor. Well, there are a number of sensors being studied to detect clear-air turbulence. I think some of them are probably being used. Perhaps Dr. Bowles can address that a little bit better than I can. But forward-looking infrared is one technology that is used to detect clear-air turbulence.

Mr. Oberstar. I think our next witness will be able to respond to that question. Our next happens to be an expert in that field.

But the gentleman from New York certainly expresses the citizen side, the consumer side concern about the very, in some ways, academic issues that we are discussing. But there is that real frustration of people sitting out on that runway thinking, "Couldn't they have known just a little ahead of time?" In most cases they suspect the airlines did know and, as Mr. Molinari suggested earlier, they're packing that plane and moving it off to keep you on the runway so they don't lose that fare. I think that's a fair reflection of the citizen thought process that goes on. Whether it's accurate or not is another matter. But I think that's what most people think when they're sitting out there on the runway.

The gentlewoman from Maryland?

Mrs. **Bentley**. Thank you, Mr. Chairman.

Mr. Burnett, I was on a plane one time where we had actually touched down and the pilot suddenly realized—and I don't know how he did—that we had wind shear on the runway. They had to shoot up. I can tell you I am still very concerned, even though it's a number of years later; every time I go into that airport, I am worried about going down on that particular runway.

You mentioned that the number of weather-related accidents remains about the same. What is the percentage? Fifty percent? Sixty percent?

Mr. **Burnett**. Well, with air carrier I think it's fifty percent or fifty-six percent, in that range. Fifty-six percent of the fatal accident and fifty percent of total accidents are weather-related. That's for Part 121, the major carriers; for commuter aviation, it's forty percent of the total fatalities involve weather-related problems.

Mrs. **Bentley**. Now, you've been talking about the advances of technology—and in this day and age we're making quantum leaps in technology improvements—is it possible with adequate appropriations that in five years we could have sufficient technology or accurate enough technology to automatically keep the pilots informed of the weather conditions along the line of what we have in radar today? Mr. Molinari was asking about adding air traffic controllers to keep pilots informed, but as you said, only so many people can talk at a time. But if we had automatic information being fed in to them, would that be possible?

Mr. **Burnett**. That is what we envision. I don't know whether it can be achieved in five years or not. Mr. Laynor might shed more light on that. But that's certainly what we envision, and we know that it is possible and that it will be possible, and that certainly should be the goal and therefore free the air traffic control system from responsibility to provide the link, which will also help us improve the quality of air traffic control.

Mrs. **Bentley**. To what extent are the Safety Board's recommendations for pilot training programs reflected in the cooperative industry program—for example, that of Boeing—which we are going to hear more about today?

Mr. **Burnett**. Well, that is something that we have sought, and we are very pleased to see the FAA and their contractors that have worked for them, an outstanding group of individuals and experts in the area that have developed the training program that we think is going to have, and is now having, a major impact on improving the safety of those of us who are traveling during the summer season.

As I have expressed before, I think some of those philosophies need to be mandated regulatorily to be sure that there are no airlines that slack on the quality of training they're giving or the kinds of operational procedures that are provided.

Mrs. **Bentley**. I want to thank you and the Safety Board for really riding herd on this and other issues.

Mr. **Burnett**. Thank you.

Mrs. **Bentley**. Thank you very much.

Mr. **Oberstar**. The gentlewoman from New York?

Ms. **Slaughter**. Thank you, Mr. Chairman.

Mr. Burnett, I am sorry that another hearing prevented me from being here earlier. But I couldn't miss the opportunity to ask you a few questions on behalf of all those people I have come to know so well in airports this summer. [Laughter.]

About two weeks ago on a trip to Biloxi, Mississippi, we stopped in Memphis and discovered an absolute disaster area. There had not been a plane, apparently, from Northwest Airlines leaving on time all day.

We were told then that the plane that we wanted to go on down to Gulfport was held up because of mechanical failures. We took off about an hour later. The airlines, of course, never told us what the mechanical failure was, how serious it was, or whether it was indeed fixed. There was just sort of a sense of, "Well, let's have a go at it."

Coming back the next day, on Sunday, we discovered again that no plane had left Memphis all day. At one point they said that they were leaving for New Orleans in a plane, and a cheer went up from people who had been sitting some six hours waiting for that particular plane.

We were four hours delayed. Babies were crying for food. There wasn't any. The airport was packed, people were sitting on the floor. People who had gotten there had to hold their luggage because they would not go ahead and load it on the plane, they didn't know where they were going.

Again, the airline told us nothing. We picked up rumors here and there that a part had had to be replaced on the instrument panel, had been replaced by a mechanic from American Airlines who didn't know how to log it in for Northwest, and even though that was the Northwest hub, they were waiting for a Northwestern mechanic to come and certify this part.

Now, what all of us wanted to know on those airlines is what part do you play in that? Are you informed when a flight is four or five hours behind? Do you have any reports made to you as to what is going on, how those flights are being delayed, particularly when they are delayed because of mechanical difficulties? And do you have some oversight function to see when that happens, that it's corrected properly?

Mr. BURNETT. Well, the answer to most of those questions is, "No." The Safety Board has incident reporting standards, but they are not geared to aircraft delays or to the mere happening of mechanical problems. Aircraft mechanical problems, even in the best of circumstances, happen many times a day, and the Safety Board would be overwhelmed by asking for reporting that sort of situation, although the FAA has certain monitoring programs to oversee that process.

I understand very much the frustration. In the month of February, on the same airlines that you've mentioned, I had in three trips four major delays, either involving missed connections or several hours' delay resulting from mechanical problems with the aircraft on the airline.

I would encourage everyone that sees that situation not to jump to the conclusion that there is a safety problem. In fact, I think it may very well suggest that the airline is being very disciplined in following its minimum-equipment list and that the circumstances that you relate, although very frustrating in terms of delays, in fact may reflect a very close attention to their safety duties.

The concern that I would have about that is that there probably may not be as much programmed downtime for their aircraft in order to do the maintenance before it has a problem that results in mechanical delays.

Ms. **Slaughter**. Is that not a safety hazard in itself?

Mr. **Burnett**. Well, it could be, but not if in fact they are following the rules in the way that they analyze and act upon those problems. What would become a problem is if they went on one step further and didn't follow the rules.

But although I also, as I related, join in the frustration that many travelers are now feeling about the delay situation, I have actually advocated air traffic control policies that will increase the number of delays. I think it's very important that we not allow the frustrations that we are experiencing to lead us to adopt policies that would be negative to safety. I don't think we should necessarily conclude that all the problems out there that we are seeing are in fact safety-related.

Ms. **Slaughter**. Well, I think all of us would agree with you, we don't want them taking off either if they can't make sure that mechanical problem is fixed. What I want to know from you is how do we as passengers know, in a crowded airport, when hundreds of people are clamoring to get on, that they're not just saying, "Well, let's just go ahead." Who has that final say in that situation?

Mr. **Burnett**. Well, the airline has the responsibility. There is no one there immediately looking over their shoulder. Under certain circumstances there might be an FAA inspector there, but they're spread far too thin to do that on a routine basis.

In fact, I think traditionally our regulatory inspection program has worked well in order to protect the passengers in that regard. One of the new things we have in the equation is a potential temptation to avoid the regulations because of a new competitive environment, and the FAA, a few years ago when deregulation was introduced, was not at a level that was able to give us assurances that the system was going to be adequately regulated and monitored in the face of a competitive environment. I think they are moving forward now to get us to that point.

I wish I could say that I think they're already there. I don't. But they are moving ahead in that regard. I think many of the things that you have just cited, despite the aggravation and frustration of them, indicates that the system is working, at least on the safety side. It may not be working on the scheduling side and on the consumer protection side.

Ms. **Slaughter**. Well, I think you brought up an important point that this new competitive environment—which I think is this merger madness—it's worse this summer, isn't it, wouldn't you say? Hasn't air travel been considerably worse this summer?

Mr. **Burnett**. Well, the fact is that——

Ms. **Slaughter**. Rather than getting better, isn't it getting worse?

Mr. **Burnett**. The amount of air travel is increasing. It's increasing because it's become increasingly economically attractive to people to travel by air. That hasn't been good for bus lines, but it has been for aviation and aviation activities.

But as I think the Administrator mentioned in a newspaper interview this week already, I think the FAA was caught short by the kind of increases that we were going to have in traffic, and I don't think it's something we should point our finger at the FAA for because I don't believe anybody really anticipated how well deregulation was going to work in increasing the demand for aviation services. In fact, that increased demand and the airlines' response to it has caused us a lot of problems.

Ms. SLAUGHTER. One other thing, Mr. Burnett. If you could just explain to me what happened in Washington last Friday night. [Laughter.]

Many of us who waited in the airport three or four hours were told three different things, all of which I guess would come under your jurisdiction. One is it was a weather problem. The second, that the computer had gone down. Third, that the radar was out in the whole Northeast. Just as a matter of curiosity, as one who sat there for three or four hours, could you tell me what that was?

Mr. BURNETT. None of those things come under our jurisdiction unless they had produced an accident. Fortunately, they did not. I was not trying to fly out of Washington, I was trying to get back in Friday, and I got back in after midnight and was not aware of all that problem. But the Safety Board investigates accidents and incidents that are almost accidents, and we, to my knowledge, have not come into any loop on that, although certainly many of the ground-hold policies that we have recommended may have contributed to planes being held on the ground and, hopefully, perhaps contributed to the fact that we did not have any accidents as a result of that weather system.

Ms. SLAUGHTER. Thank you.

Mr. OBERSTAR. The gentlewoman will have the opportunity to ask those questions of the people who are responsible for that information, the FAA and the DOT, later on. The FAA has the responsibility for keeping track of maintenance situations such as that you described a moment ago, and the DOT has the responsibility for maintaining records on consumer affairs, consumer complaints about delays. They will be up here and be ready to answer those questions—probably even excited to do so.

Mr. Burnett, would you say that it is fair to characterize it that the FAA will not complete its objectives of more accurate and more timely communication of weather detection and dissemination for several years yet?

Mr. BURNETT. That's true. And even under the program that they have adopted within the National Airspace System Plan, the accomplishment of those goals is going to depend in many cases on budgetary and fiscal factors and they are going to have to have the support of the Administration and the Congress in order to complete the goals that they have laid out.

Then there is also going to have to be adequate regulatory action to be sure that the airlines uphold their end of the action by providing the equipment, the onboard equipment that's necessary.

Mr. OBERSTAR. Further, isn't it accurate to say—would you agree or disagree—that there is no single weather detection system, there is no single approach to weather safety, that instead it requires a combination of many factors, many of which you have already cited, and perhaps even a combination of technological advances, some of which are already in development and some in deployment, in order to accomplish that objective?

Mr. **Burnett**. The many different disciplines from psychology of aviation training to meteorology to communications science, all of those have to go into gear into one integrated system, which is one of the reasons that we are very much encouraged with the fact that the FAA has finally put this together in an integrated plan and has produced a plan that seems good and is moving forward on.

Mr. **Oberstar**. You have set a very fine framework for the balance of our hearing today, and I think those are the key factors that we will explore in further detail with other witnesses.

Mr. **Burnett**. Thank you.

Mr. **Oberstar**. Thank you very much, Mr. Burnett, and Mr. Laynor, for being with us and for preparing splendid testimony.

[The prepared statement of Mr. Burnett follows:]

National
Transportation
Safety Board
Washington, D.C. 20594

Safety Information

Testimony of

Jim Burnett, Chairman

National Transportation Safety Board

before the

Investigations and Oversight Subcommittee

Committee on Public Works and Transportation

House of Representatives

Regarding

Hazardous Weather and Aviation Safety

June 30, 1987

Mr. Chairman, Members of the Committee, I am pleased once again for the opportunity to appear before you to discuss hazardous weather and aviation safety. Your continued interest and vigilance are to be commended.

Weather conditions associated with thunderstorms and convective activity, conditions prevalent during the late spring and summer months, continue to be a leading cause/factor in accidents involving U.S. civil aircraft.

Accident data analyzed by the Safety Board for 1980 to 1986 showed that weather conditions associated with thunderstorms and convective activity were cited 545 times in accidents involving U.S. civil aircraft. Many hazards of these conditions include hail, lightning, tornadoes, turbulence and heavy rain.

Although lightning strikes have been cited as a cause/factor in accidents only twice during this seven year period, lightning strikes may become a more frequent and more dangerous threat to the new generation of aircraft containing composite materials, "glass" cockpits, and "fly-by-wire" technology.

The most significant hazards to aviation are thunderstorms and low altitude windshear which have resulted in over 600 fatalities since 1973. In fact, the 1980 to 1986 air carrier and general aviation accident data indicates that thunderstorms and windshear were cited 68% of the time. The most important facet of this problem involves the detection and rapid dissemination of severe weather information to pilots.

Following the thunderstorm related crash of a Southern Airways DC-9 at New Hope, Georgia on April 4, 1977, the Safety Board recommended that the FAA develop an aviation weather detection system for both the enroute and terminal areas capable of displaying multiple weather echo intensities. We also recommended that this information be transmitted to pilots via the controller as a safety advisory or via an electronic data link. We again made a similar recommendation following the thunderstorm accident involving an Air Wisconsin Swearingen SW-4 commuter, near Valley, Nebraska that occurred on June 12, 1980. These recommendations are in an "Open -- acceptable action" status, as the FAA continues the development of doppler radar to provide this capability.

Also following the Southern Airways accident, we recommended that the FAA formulate procedures for the timely dissemination by air traffic controllers of severe weather information to flight crews. In response to this recommendation, the FAA and the National Weather Service established the Center Weather Service Unit in the Air Route Traffic Control Centers.

We believe the Center Weather Service Units have performed an important function in alerting controllers to potentially hazardous weather conditions. However, we have identified problems in the dissemination of information concerning rapidly developing convective storms to the terminal area. We have also become aware that Center Weather Service Units need equipment improvements to better perform their function. We urge the FAA and National Weather Service to work together to improve the dissemination process and to hasten equipment improvements at all Center Weather Service Units.

Following the Pan American accident at Kenner, Louisiana on July 9, 1982, the Safety Board issued 14 recommendations to the FAA. These recommendations concerned the subject of information regarding hazardous meteorological information and were grouped into six categories: 1) observation, 2) dissemination, 3) operation limitations, 4) research and development, 5) operational training and 6) flight instrumentation. Many of the recommendations dealt with improvements to the current Low Level Wind Shear Alert System (LLWAS) in the use, display and processing of the data and the location of the wind sensors. All of these recommendations were accepted by the FAA.

Three years later, another tragic windshear accident occurred involving an L-1011 aircraft at Dallas/Ft. Worth International Airport on August 2, 1985. The accident claimed the lives of 134 passengers and crewmembers. One person on the ground was killed.

Following the accident, the Safety Board issued 17 additional Safety recommendations to the FAA, the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS). The recommendations were intended to correct identified deficiencies in the areas of operational procedures, training, air traffic control, and weather instrumentation and dissemination. About three quarters of the responses we have received and evaluated have been favorable to these recommendations.

Although the FAA has been involved actively in trying to reduce the low altitude windshear hazard since 1967, it was only recently that the FAA embarked on developing a systematic approach to the windshear problem. The FAA's Integrated Wind Shear Program Plan which is based on information and assistance provided by the Safety Board and others in both government and industry. It is composed of the following program elements:

- Education, Training, and Operational Procedures

- Ground Sensors for the Detection of Low Altitude Wind Shear

- Airborne Sensors and Flight Guidance Systems

- Terminal Information Systems

- Low level Meteorological Hazard Characterization

The education, training, and operational procedures element of the program consisting of windshear training aid documents and videos has been released to industry. The training aid is designed to present an effective means of educating and training flight crews to recognize and avoid the windshear threat. The development of the training aid and videos was undertaken by the FAA and a consortium of aviation specialists from the Boeing Company; United Airlines; McDonnell Douglas; Lockheed-California; Aviation Weather Associates; and Helliwell, Inc.

The FAA and these aviation specialists should be commended for their work in developing this training aid and for its distribution. The training aid represents a significant step in lessening the hazard to aviation presented by low altitude windshear. In addition, the Safety Board strongly supports the other ongoing elements of the Integrated Wind Shear Program.

Detection of severe meteorological conditions associated with thunderstorms and convective activity, and dissemination of that information in a prompt manner to flightcrews, is what the Safety Board views as a primary weather problem. Detection of severe meteorological conditions can be accomplished by use of systems such as reflectivity radar, both ground based and airborne, doppler weather radar, airborne windshear detection and warning devices, and enhanced low level windshear alert systems. Dissemination of the information can be through data link to the cockpit, through a meteorologist, dispatcher or air traffic controller. However, development of many of the previously noted detection and dissemination systems represent long term efforts.

Although we are aware of the FAA's position regarding the use of current reflective weather radar systems by tower controllers, we believe that there are benefits which could result from the use of such radar systems without significantly affecting the controller's workload. However, we do not intend to imply that current radar systems should be a substitute for or should delay the implementation of terminal doppler weather radar which shows the greatest promise for effective detection.

Until the various technological "black box" advances are available, pilots -- their judgment and actions -- will remain a key prevention tool in avoiding weather related accidents.

We must enhance LLWAS and provide the enhanced information to pilots in a flightcrew-usable, timely format. We must stress the importance of making and disseminating pilot reports (PIREPS) in a timely manner to terminal air traffic control facilities for prompt dissemination to flightcrews. We must heighten the awareness of pilots to the hazards of thunderstorms and convective activity. We must train pilots in escape techniques from inadvertent windshear encounters. We must equip Center Weather Service Units with state of the science equipment with which to perform their function. We must streamline the dissemination of NWS generated data to Air Traffic Control Facilities and flightcrews. Finally, we must stress the avoidance by pilots of any thunderstorm or convective phenomena which may be a potential threat to aircraft safety.

All of these things must be accomplished in the short term to prevent the continued occurrence of accidents related to thunderstorms and convective activity.

That completes my formal testimony, Mr. Chairman. I would be pleased to respond to your questions.

Mr. Oberstar. Our next witnesses are Dr. John McCarthy, Manager, Research Applications Program of the National Center for Atmospheric Research; and Mr. Cecil Rosen, Director for Aeronautics, Office of Aeronautics and Space Technology at NASA.

Would you gentlemen please come forward to the witness table? Raise your right hand. Do you solemnly swear that the testimony you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. McCarthy. I do.

Mr. Rosen. I do.

Mr. Oberstar. Thank you. We greatly appreciate your participating in the hearing today, the preparation that you have put into your presentations, and for the splendid range of information which you are providing for the committee and for the public.

Dr. McCarthy, would you begin, please?

TESTIMONY OF JOHN McCARTHY, MANAGER, RESEARCH APPLICATIONS PROGRAM, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH; AND CECIL ROSEN III, DIRECTOR FOR AERONAUTICS, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. McCarthy. Thank you very much, Mr. Chairman.

I am John McCarthy, and I am manager of the Research Applications Program at the National Center for Atmospheric Research at Boulder, Colorado. At this position I direct low-altitude wind shear research and have approximately thirty employees that are primarily engaged in wind shear research activities.

It is a great pleasure to come back to this committee and give you an update on low-altitude wind shear activities that are pertinent to the mitigation of what we have already heard is such a severe aviation hazard.

As you know, I have been deeply involved in the identification of the scientific nature of the hazard, particularly and with great emphasis on the convective microburst form of wind shear. I have been involved in this activity now for about ten years. It is a pleasure to follow Jim Burnett, who has been watching this activity and giving tremendous insight into the need for it over the last few years.

The Chairman has very clearly stated the serious nature of low-altitude wind shear as being a source of great loss of life to air carrier passengers in the United States. It is furthermore my opinion that the FAA in conjunction with other Federal agencies, the private sector, and academic institutions, has developed a rather complete plan to mitigate the threat, and I will be addressing several elements of those.

I am going to briefly go over my testimony, and then with your permission, I would like to bring you up to date with a few slides showing some of the more recent research results that we are dealing with.

Mr. Oberstar. Your entire testimony will appear in the record in full. You may summarize as you may choose, and the same for Mr. Rosen.

Mr. McCarthy. Yes. It has been mentioned here this morning quite a bit about the low-level wind shear alert system (LLWAS). It is correct that it is the only operational ground-based system that is in operation in the U.S. It is now operational at approximately ninety airports. It is the intention to have them installed at one hundred ten airports total.

The system was originally designed to detect simple wind shifts, especially gust fronts coming from thunderstorms. The current six-station system is really quite inadequate to detect the most serious form of wind shear, which is the microburst. This is due primarily to its rather crude resolution and archaic detection computer software, and also to a rather confusing controller display capability. I will show examples of this in my slide presentation momentarily.

Following several years of taking a look at the low-level wind shear alert system in conjunction with a program that I codirected, the Joint Airport Weather Studies project, which occurred at Denver in 1982, we have been working with the FAA to come up with a new system to improve the LLWAS system. It will be an eleven-or-twelve-station network. It will have much improved microburst detection capability. It will have much better computer algorithms for detection. And finally, it will have a much improved message that will get to pilots in a way that we think will be much less confusing than the current system.

There is a full demonstration of the new LLWAS system that is about to begin in Denver at the end of this month, and I will show you some examples of that.

Now, to be clear, I want to state that even the enhanced LLWAS system is only a partial solution to the low-altitude wind shear problem at best. There are a number of limitations associated with the system, even as enhanced. My opinion is that the FAA should maximize the capability of the system, given that it is the only system that is out there right now. And that has been the basis of pursuing, in my view, the research that improves it.

Now, an awful lot of our work at NCAR has been examining the scientific basis of the threat to aviation, again with a focus on the microburst. One of the more important things, in my opinion, that we have done in the last year or so is to incorporate the aviation system user—namely, controllers and pilots—into the process of identifying the hazard in an operationally useful manner. We have become deeply involved in a process of transferring our scientific work into applications.

An important part of the LLWAS enhancement—and it also relates to the terminal Doppler enhancement of the Terminal Doppler program Weather Radar (TDWR)—is the formation of something called the User Working Group. This group consists of pilots from commercial and general aviation sectors, air traffic controllers, and scientists and engineers who are technical providers. They have met several times to provide advice on determining what aviation system users require in terms of quantitative severe-hazard warnings in order to make safer avoidance decisions.

The upcoming test at Denver with the enhanced LLWAS will focus on a runway-oriented wind shear alert message derived from the user group advice. In addition to implementation of the

LLWAS, a lot of the user group dialogue is playing a major role in TDWR.

Now let me turn to the Terminal Doppler Weather Radar program, which is a very major program and one that has come up here a lot this morning. Under the sponsorship of FAA and in conjunction with MIT Lincoln Laboratory, I direct the NCAR portion of the effort designed to develop a prototype automatic detection and warning system to warn pilots and controllers of the presence of wind shear at a number of terminal areas.

The effort includes algorithm development, which is the critical part. We have heard something about hardware versus software. It is the algorithm that is being used in an artificially intelligent manner to come up with automatic detection. I will talk a little bit in a few minutes about what we did manually and why the automation is so critical.

The next thing that we're doing is verifying that the algorithms are working correctly. That is, again, a very important part: how good are they; what is the accuracy; can we provide an automatic product at a very high detection probability at a low false-alarm rate?

Currently, those radars are operating at Denver—I will show you some of that in a minute—in a test mode. We are not producing an operational product this summer, waiting until we demonstrate conclusively that the algarithms are quite accurate.

Another part is coming up with air traffic control displays that are pertinent to this new type of information, and including the formulation of appropriate warning messages to pilots. And finally, a full operational demonstration of that system is planned for the summer of 1988 at Denver.

Now, this leaves the FAA procurement of terminal NEXRAD radars as well as terminal Doppler weather radar systems. These are two systems. I believe Mr. Mineta referred to the similarities of them. They are both designed to address the problem. One takes the current NEXRAD procurement and moves seventeen radars into action in the terminal area, and then the plan for the follow-on procurement is to cover a much larger number of airports with a similar system, although they're different in some respects.

It is my understanding now that TDWR radars will be deployed starting in 1990 at seventeen airports. Actually, sixteen are planned for operational airports, and one is for a development site. I understand that the desire of the FAA is to have approximately one hundred terminal Doppler weather radars procured and deployment beginning about 1993.

The terminal Doppler weather radar offers major advantages over other systems, including, as mentioned, I think, by Bud Laynor, the significant promise of wind shear warning prior to the phenomenon actually striking the ground. So that is a very important part, and I will make reference to that in my slides.

Mr. **Oberstar**. When you refer to wind shear, do you include by definition microburst as a wind shear phenomenon?

Mr. **McCarthy**. Yes.

Mr. **Oberstar**. In other words, the state of definition of the problem is such now that microburst is not considered a separate phenomenon but a phenomenon of the wind shear type?

Mr. McCarthy. Yes. A microburst is simply a type of wind shear. It happens to represent ninety or ninety-five percent of the accident causes.

Mr. Oberstar. Yes.

Mr. McCarthy. So when I am talking about something coming down, I am really referring to the microburst. Your point is well taken.

Mr. Oberstar. Fine.

Mr. McCarthy. I want to make sure that I don't say that Doppler radar is the end-all, because we will hear shortly that it is not, it only represents an important part of the puzzle. And I will make reference to that. It is not a complete solution to the problem, but it is a very important one.

I will mention briefly the Convection Initiation and Downburst Experiment, (CINDE) which is ongoing at Denver right now. It is a two-month program that is being funded by the National Science Foundation, the National Oceanic and Atmospheric Administration, and the FAA. It is a program that is addressing the use of Doppler radar to forecast when and where a thunderstorm will form. Now, this is not a wind shear problem, but it sure is a serious weather hazard, as I understand happens around here on Friday evenings.

The point of the CINDE program is to identify precisely when and where a thunderstorm will form. Currently, for example, the forecast for Washington in the aviation context or a public context might say there is a twenty percent probability of thunderstorms in the D.C. area from early afternoon to early evening. A futuristic example of a Doppler-derived thunderstorm point forecast might be a thunderstorm is expected to form two miles west of Denver's Stapleton International Airport in forty-five minutes or at 1535 MDT, moving to the east at fifteen miles per hour.

Now, this specificity in a forecast is the kind of thing that will help the air traffic controllers deal with capacity and delay problems. So there are some very interesting aspects to that kind of research that I think is pertinent to the discussions that are going on here this morning.

I will mention briefly—and not to usurp Mark Kirchner's testimony a little bit later—but I was very fortunate to be involved as the meteorologist member of the Boeing-led Federal Aviation Administration Wind Shear Training Aid. You will hear a lot more about it later this afternoon.

I just want to say that the concept focuses on the critical need for pilots to make more timely wind shear avoidance decisions and finally to provide pilots with a means of recovering from wind shear should they inadvertently encounter it, although the recovery technique won't work in all circumstances.

In my view, it is absolutely critical that all pilots receive improved wind shear training. While the FAA Wind Shear Training Aid addresses the needs of commercial airline pilots, there remains a major breach in critical knowledge to transfer to the remaining pilots in the community, especially among business and private pilots. I recommend that a very high priority be placed on continuing the pilot wind shear training technology transfer process to the remainder of the community.

I endorse the FAA's advanced notice of proposed rulemaking that, if it continues to a rule, will require advanced wind shear training, but we must make sure it gets through to the entire piloting community rather than just commercial airline pilots.

In summary, I have been up here a few times, and I want to say that extraordinary advances are really occurring in low-altitude wind shear technology development. The LLWAS is undergoing testing for an improved version that will have some substantial advantage. The Terminal Doppler, Weather Radar program is moving ahead. We will hear later on that airborne systems are making some progress. And finally, training is definitely making major leaps ahead.

There is no single solution to this problem. And I am echoing what other people have said. The FAA has recently published the Integrated Windshear Plan, which outlines a systematic approach to the problem, and I strongly endorse that this plan be continued to fruition. It is in response to the National Research Council's study entitled "Low-Altitude Wind Shear and its Hazard to Aviation," on which committee. I was fortunate enough to serve.

It is very important that the effort be continued. Wind shear is a very serious threat. As long as the Federal Government in conjunction with the aviation industry continues to press for this complete program, there is considerable optimism that we will see low-altitude wind shear accidents with much less frequency.

Perhaps instead of the current accident rate of once every twelve to eighteen months, we might see wind shear accidents relegated to once every twenty to thirty years.

That is all I really wanted to say formally, and I do have some slides that I would like to show you if there is an appropriate time for that.

Mr. OBERSTAR. That would be an extraordinary accomplishment should we be able to achieve the goal of once every twenty to thirty years. We share your objective, but it would be equally optimistic that technology could lead us there, but more importantly that the will to get there will stay on course. That is the purpose of these hearings.

Mr. Rosen, would you like to proceed?

Or do you want to give the slide presentation and then go to Mr. Rosen?

Mr. MCCARTHY. It might make sense to run through the slides now, if that's an appropriate thing.

Mr. OBERSTAR. Fine. That is up to you. You two are working together and we know your interest in sequencing properly.

[Slide presentation.]

Mr. MCCARTHY. Can you see these slides all right, Mr. Chairman?

Mr. OBERSTAR. Yes.

Mr. MCCARTHY. I just want to give you an update on a few things in wind shear. Some of these slides are from the Boeing wind shear training program. Again, someone was trying to describe a microburst a little bit earlier as a downflow and a spinout near the ground. There is nothing really new about this, except it's a rather pretty picture of it.

All microbursts are caused by precipitation coming out of a convective cloud. Sometimes it's very heavy rain near the ground. Sometimes it's very light rain which we commonly see in the western part of the United States. There is also an intense vortex curl that frequently occurs on the spinout from these microbursts. So I just wanted to set the context.

The other thing about a microburst is that it's a very simple flow. It's simply a downdraft that comes out of the cloud and gets near the ground. The interesting thing about a microburst is that it only lasts about five or ten minutes. The other thing about it is that it's very small in horizontal extent, typically about a mile and a half to two miles across.

As Chairman Burnett said earlier, we have lots of microbursts around. The problem is—or the good news really—is that they are so small and last such a short time that the probability of an encounter is still quite small, and that is why we are not having as many accidents as we could, based on the number of events that we see.

Mr. OBERSTAR. Could you address at the same time—or are you—the windspeed involved?

Mr. MCCARTHY. Yes.

Mr. OBERSTAR. I think that's a very important factor.

Mr. MCCARTHY. Now, here is an artist's rendition of Delta 191 at Dallas-Fort Worth in August. Delta 191 encountered an extremely strong microburst, a strong headwind increase, a very major downdraft, and then finally a tailwind, and then the vortex curl associated with the spinup of the microburst. So that's the most recent of the major air carrier accidents involving wind shear.

Mr. OBERSTAR. When you said "extremely strong," what airspeeds of the weather phenomenon itself are you referring to?

Mr. MCCARTHY. Basically the headwind-to-tailwind change, which I will talk about in detail in just a moment here, was about seventy knots, which is near the upper end of aircraft-measured wind shears. It's one of the very strong cases. I will look at that in a second.

This is a map that shows where in the United States we think microburst wind shear accidents have occurred, and you can see that they are just about everywhere in the United States except the northwest part, Seattle area, that kind of area.

The bottom line is that where thunderstorm-type events occur, microbursts occur. There is also an international distribution, but we have much less information on many of the international accidents.

Here is a picture of a microburst over Denver, and I simply want to show you that not only is a microburst occurring in very heavy rain, but this is a thunderstorm producing a very light rainshower which in fact evaporates before reaching the ground. From the runway to the cloud base it's 12,000 feet. So it's a very benign-appearing cloud, yet the wind differential on this runway is a headwind-to-tailwind of sixty-five knots.

We are using these kinds of pictures in the training program any chance we get to describe the otherwise benign appearance of this as being a very hazardous situation.

Now, here is a sequence of photographs taken by a colleague of mine, Mike Smith, in Wichita, Kansas, which shows something that I think is probably similar to what the pilots of Delta 191 might have seen. It shows a very benign-appearing rainshower, not yet reaching the ground. Only two minutes later, we show the rainshaft now on the ground.

This is actually a rather ordinary-looking rainshaft. But if we wait for two minutes longer, we begin to see that there is something happening on the edge of the rainshaft. What is happening in this case is the downdraft has hit the ground, has begun to move out in both directions, but we are only looking at one side, and we are beginning to see the development of this sudden outflow which is associated with the microburst. Here it is as a full vortex curl of air rushing out of the rain.

Now, the unfortunate thing is I think most pilots are not trained to recognize this as other than just an ordinary rainshower. However, it is a clear visual evidence of a microburst.

Mr. OBERSTAR. How far out from the center does that vortex extend?

Mr. McCARTHY. I don't have the information in this particular picture, but typically this is probably about a thousand or perhaps two thousand feet. It will continue to move outward and get larger. When it gets larger, it becomes less hazardous.

Mr. MINETA. Mr. Chairman.

Mr. OBERSTAR. Mr. Mineta?

Mr. MINETA. Doctor, this is fine from the ground. But when you're sitting there in a cockpit coming in at 3,000 feet, what do you see?

Mr. McCARTHY. Well, in my opinion, this kind of situation would be visible if you're on an approach to an airport located in this vicinity. You have to keep looking at it. But any time, in my opinion, from the air, as long as you're not in the cloud, if you have a visual view of this, this is a clear indication that there is something going on there. I would think it would be quite similar—your point is well taken—this is taken from the ground, and it's a lot easier to sit here and stare at the picture.

Mr. MINETA. So as you're looking down at it, is there some way to be able to determine that vortex that you are illustrating here?

Mr. McCARTHY. Well, I am not sure if I have one of my vortex photographs in here, but this feature should be visible from the air, like from the outer marker inbound, as long as you have a clear, uninterrupted picture of the visual sight ahead of you. But of course, in many cases you do not.

All I am saying is that sometimes you may see this and you must pay serious attention to it. It's very obvious that there are many times when you will not see this, but the feature can still be present. But if you see this, pay attention; that is the point of this.

Okay. I put this picture in here to show an asymmetrical microburst because sometimes the headwind-tailwind change is asymmetrical. You may have more flow in this direction then in this direction. The headwind-tailwind change is the windspeed from this location to this location, so that when we talk about a headwind-tailwind change of seventy knots, it's the difference that an aircraft would encounter when flying through the microburst.

That comes to the next figure, which is the one you've been asking for. This is Doppler radar-derived wind change across the microburst. So thirty knots, fifty knots, seventy knots. That's the headwind-tailwind change. This is the number of events. These happen to be data measured at Denver, but recent experiments by MIT Lincoln Laboratory at both Memphis and Huntsville confirm these numbers being very representative.

We have superimposed on here a number of celebrated and not-so-celebrated accidents. The first one on here is JFK, which is the crash of Eastern 66 at Kennedy Airport in 1975. It is only a thirty-knot headwind-to-tailwind change, which is not a lot of change; it is a relatively mild change that caused that accident.

Here is the Pan Am 759 accident at New Orleans in 1982. It shows here about forty-two knots. Again, less than the average value for microbursts that we have measured.

These are several incidents. This is an incident at Denver, I believe, with United. Here is another incident; this is at O'Hare in Chicago. And here is another incident which has been referred to this morning which is an accident at Denver in 1984, which was about a sixty-knot change. Here is the Dallas-Fort Worth accident two years ago, and here is the Continental 426 accident at Denver in 1975. So that average to greater-than-average values can easily cause accidents.

I will point out to you just to make sure that you realize Washington is not out of the story the microburst way out here at 204 knots is the Andrews Air Force Base microburst of 1983, by far the strongest microburst ever seen. It in fact occurred shortly after the landing of Air Force One.

So it is very serious business indeed, and this represents the kind of velocity changes that you are taking a look at.

I will only mention a couple of things about the FAA's education training procedures program, the Windshear Training Aid. This represents the Integrated Windshear Plan. The objective of the strategy—and again I am just going to show a couple of pictures that will amplify your testimony a little bit later—is to avoid known wind shear and then to recover from inadvertent encounters.

The thing that has come to us in examining many accidents is that avoidance—that you are in a wind shear—is very difficult to recognize and the time available for a flight-crew to recognize that you are in a hazardous wind shear may be as little as five seconds or as long as fifteen seconds. We have been thinking five to seven seconds, which isn't a very long time. So that if you're in a very bad situation, you have to take action very quickly to avoid an accident. Crew coordination is very important, and it's very important to maintain flight path control to get out of it. I will show you some examples of that in a second.

Finally, the whole idea of the recovery technique is to trade what I consider in the simple way kinetic energy for potential energy by simply raising the flight deck angle up in such a way that the airspeed decreases and you get increased separation from the ground. It's a pretty simple concept, but in detail more complicated.

This is a takeoff scenario. The white line is where you would like to go, which is up, up, and away. If you encounter a microburst on the runway or just after takeoff, unfortunately you follow the yellow line if you don't exercise a recovery technique, or if the microburst is so severe that the recovery technique won't work. And unfortunately, this is the scenario of Pan Am 759, the incident of Continental 426 at Denver, and it ends with what some people call a "premature impact with terrain." For the recovery technique, if it's successfully conducted, you follow the green line. So that is a takeoff scenario.

And a landing scenario looks something like this. This is similar to Delta 191, and Eastern 66, where you encounter the microburst on approach and you end up crashing short of the runway. The white line is where you'd like to go, and the green line is where you might be able to go if you're able to execute a recovery technique.

Mr. OBERSTAR. What is the frequency of microburst encounter on takeoff as compared to landing, and how is that reflected in the accident statistics?

Mr. MCCARTHY. Okay. Is Bud still here? Because I am not sure of the exact number. I believe it's about fifty-fifty. I don't think that there is a predisposition accident statistics-wise on takeoff or landing. I think the attitude was in executing the recovery, that you're better off doing it on takeoff than on landing because on landing you have to make a turnaround and get an aircraft already coming down towards the ground to get away.

But statistically, I think it's about a fifty-fifty split. But I am not certain of that; I would have to check into that.

Again, we cannot overstress avoidance is the best rule. Much of what I will be telling you from here on is stressing ways to more effectively avoid. The recovery technique I will move quickly through here because I know it will be discussed in greater detail later on.

Now, I want to point out one of the first cases where the recovery technique was used and was referred to by the NTSB. On the 31st of May in 1984 there was a classical microburst with a delta change of about fifty knots. It's actually closer to sixty knots. There was precipitation evaporating before reaching the ground. This was at Denver. The aircraft ahead of the United jet reported a twenty-knot loss—that's a pilot report of airspeed. There was dust blowing across the runway. The pilot said, no big deal, there is construction out in the middle of the airport, no problem.

The low-altitude wind shear alert system was going off, but the pilot was getting, in his view, an unclear picture of what that meant, and the pilot did use an energy-trade procedure, which is a pitchup maneuver to trade airspeed for altitude, basically to do the recovery technique. And we also had a Doppler radar operating for another program, so we knew it was a microburst.

It happened, taking off on this runway in Denver in this direction to the north, and the airplane went off the end of the runway—this won't show up too well—the aircraft went off the end of the runway at about ten foot altitude, used up the whole runway, came across the grass at maximum power. What this picture shows is the grass burned up along this stretch of grass right here because it was just above the ground at a high deck angle so the exhaust was doing what the lawnmowers usually do. And then the aircraft went through the localizer antennas and took out an antenna right in the middle of the array here.

The next picture shows a tire mark from one of the aircraft wheels. And another thing about this picture is it shows a classical microburst in the background.

Finally, here is the antenna sticking out of the belly of the aircraft. The aircraft, needless to say, got away, and that is the good news in this particular thing.

What we did following this is the CLAWS project—which is the Classify, Locate, and Avoid Windshear project—where we brought Doppler radar to the airport at Denver and provided manual meteorologists' developed products, which this is an example of a manually produced product where we simply indicated on a piece of paper where weather radar indicated a microburst two miles north of Stapleton, wind shear may be fifty-five knots. This information was actually broadcast to pilots, and it was very clear that these kinds of detections could take place well except it was done entirely manually by meteorologists doing the detection work.

The pilot who filled out this questionnaire—we had some questionnaires in the cockpit—had a fifty-five knot loss in the headwind component at 350 feet above the ground on landing, and claimed that the advisory saved his airplane. So that gave us some good news to proceed into some detection and warning work that I will report on now.

Here is another picture taken from the tower at Denver. Again it shows a classical microburst picture. Again you can see this on approach. Even though this is taken from the tower, this is the classical foot outflow that we talked about earlier.

Here is another picture of a microburst basically hitting the control tower at Stapleton. Here the runway is just south of the control tower. Here is the blowing dust associated with a direct centerfield hit of a microburst, which is why blowing dust can be such a significant event in identifying a microburst.

Finally, I can't help showing this picture. This is taken from the tower. What has happened here is that a line of thunderstorms that have microbursts have occurred east of the airport, and we are seeing the precipitation coming down with several microbursts.

In the outflow of a microburst we frequently have a tornado feature. This is a tornado—we call it a "gustnado." It is not a classical tornado because it is not connected to a cloud base. It did $1.5 million worth of damage to the city of Aurora. Here is an airline jet coming through the middle of the tornado. That is with the headlight on.

So, yes, it can be a zoo out there, and we are trying to bring this kind of picture to the attention of pilots in general.

Let me get into the detection and warning. Here is a low-level wind shear alert system. This is the way it's currently configured at about ninety airports. It contains six sensors located around the airport, including the centerfield site here. When there is a fifteen-knot change between the outlying sensor and the centerfield, an alert goes off in the tower cab, which is then provided to pilots.

The problem with the existing system is that the microburst is frequently smaller than the spacing between the sensors. So the bottom line is that the probability of detecting a microburst event, if it falls inside the system, is deficient. So also, any microburst that is above the ground or outside the system, of course, cannot be detected.

The display that appears in the tower cab simply spills out all of the windspeed and directions from all the different sensors. So if all the sensors go off and indicate wind shear, the controller must read all these numbers over the air to the pilot. That is part of the serious confusion with the system, because the pilot has to get all these numbers and assimilate what that means in terms of what the wind shear is. There have been some studies done that suggest that that is a problem because it is not easy enough to use.

Now, what we're doing at Denver in an enhanced system is that we have doubled the number of sensors. Here is the old system. Here is the new system, and the spacing between the sensors is half of what it used to be. So the probability of detecting a microburst is much greater.

We have also gone to a runway-oriented message, which will be tested this summer and serves as the basis of the new detection system. So here is a runway here. Here is the departure zone, two mile, one mile, on the runway; and then approach one, two, and three miles.

The new wind shear message will be: "Microburst wind shear alert. Expect thirty-knot loss on this runway. Location," let's say, "two mile final and intensity increasing." In fact, we won't have intensity this summer. But instead of reading a bunch of numbers around the airport from the old LLWAS, we are going to have a runway-oriented message that gives the specific loss that the pilot is looking for.

Here is a display that a supervisory controller may eventually see which shows in red where the microbursts are located with respect to the runway configuration. In Terminal Doppler Weather Radar, again we found both in our work at NCAR and Professor Fujita at Chicago and MIT Lincoln Laboratory that Doppler radar located near an airport can come up with a clear, unambiguous picture of a microburst.

This picture, which I won't go into detail, can be only a microburst. Nothing else will make this particular picture on a Doppler radar. These are windspeeds.

Now, here is what a microburst looks like.

Mr. OBERSTAR. Now, at that point, Doctor—and we are going to have to interrupt the hearing because we are going to have a fifteen-minute roll call and a series of recorded votes.

But the previous slide information, as I understand LLWAS now, cannot uplink real-time information to the aircraft. Is that correct?

Mr. MCCARTHY. No. The information from LLWAS can be uplinked. It is currently being uplinked only by voice. So the uplink issue is simply a matter of uplinking the information. So in fact there are plans to do uplink work with the LLWAS at New Orleans next summer to demonstrate that kind of capability.

Mr. OBERSTAR. And right now the only uplink by voice is via the controller.

Mr. MCCARTHY. That's right.

I have two more slides.

Mr. OBERSTAR. Go ahead and finish up those two.

Mr. McCarthy. This picture shows what a microburst looks like aloft, and it's a very important part. Here is the divergence of the outflow at the surface. There are certain features that we can see with Doppler radar for about five minutes before the microburst reaches the ground. So the advantage of Doppler radar is to look aloft at what is beginning to form the microburst, and that will serve as the advance warning that a microburst may be coming down.

Mr. Oberstar. So Doppler can give you a five-minute advance warning?

Mr. McCarthy. Well, we are in a test mode to demonstrate that part of the capability. We are very optimistic that the answer will be yes. As I said in my written testimony, what we are doing is testing this capability and demonstrating its accuracy. The advantage of Doppler over LLWAS is that we can look aloft and the research is very promising that that will produce what we call a features aloft or a microburst precursor warning down the road in about a year or two.

So that is where we are headed with Doppler radar studies with the FAA now. I think I have just one picture that shows the idea of an automatic system instead of human-developed products, and my last picture is simply the site at Denver which is located at Buckley National Guard Base where the testing is going on now.

Thank you very much.

Mr. Oberstar. All those slides are just so crucial for a general understanding of what is happening in this unique and puzzling, treacherous weather system, that at the greatest vulnerability on landing, for example, the pilot is experiencing two separate phenomena that he has to deal with in microseconds, one, an upward thrust, which would be immediately followed by a downward thrust, and the pilot may not be aware that those two are occurring in sequence, in very rapid sequence.

At the very time of encountering the upward thrust, the pilot does instinctively what he is trained to do, and that is put the nose down at the very time when he should not be doing that but should be in fact putting the nose up because the next phenomenon he is going to encounter is the downward thrust that puts his aircraft in a further downward mode. And the importance of getting this information in advance and uplinking it to the pilot is that the pilot then will be able to anticipate the weather he is coming into and do two simultaneously dangerous things.

Mr. McCarthy. Yes. Well, my view of getting the information in advance, even if it's thirty seconds or a minute in advance, or in the case of some of these systems, five minutes in advance, is to know that there is an extremely serious hazard and so go-around; that is, get out of there. My view is that if we give them very-high-resolution wind data like we can get from these systems, whether it's ground-based or airborne, that the best thing to do is to give it to them early enough so that they cannot be there when these wind changes occur; that is, to execute an early go-around.

Mr. Oberstar. Correct. At this point, we will have a series of recorded votes on the House floor, and the Chair will take an estimated forty-five minute recess to accommodate those votes, and perhaps a bowl of soup and a sandwich.

The subcommittee will stand in recess.

[Whereupon, at 12:14 p.m., the subcommittee was recessed, to reconvene at 1:00 p.m., this same day.]

AFTERNOON RECESS—1:57 P.M.

Mr. **Oberstar**. The subcommittee will resume its sitting, with apologies to witnesses and all who are interested, for the unforeseen series of recorded votes which prolonged our recess beyond its anticipated time.

Dr. McCarthy, we had just concluded your testimony, which was fascinating, about the wind shear and weather-related phenomena.

Mr. **Oberstar**. Now, Mr. Rosen, we would like to resume with your presentation.

Mr. **Rosen**. Thank you, Mr. Chairman.

I appreciate the opportunity to discuss with you NASA's research activities in the area of wind shear detection and avoidance. The FAA, with NASA participation, has led the development of an integrated wind shear program plan which addresses training, ground sensors, airborne sensors, terminal information systems, and hazard characterization, as has been mentioned several times today.

Mr. **Oberstar**. Can you pull the microphone up closer, please?

Mr. **Rosen**. Yes, sir. In response to this plan, NASA and the FAA signed a Memorandum of Agreement in July 1986 covering NASA efforts in working the airborne wind shear detection and avoidance element. In addition, NASA and the FAA have sponsored four workshops dealing with this subject. The objective of the workshops was to provide a means of obtaining industry input to the planning process and for disseminating technology and data.

This NASA/FAA/industry interface through these workshops led to the recognition that a systems approach to the airborne detection and avoidance problem was required. This includes developing an understanding and accurate models of the wind shear hazard, including heavy rain effects, to evaluate the effect of wind shear on the performance of aircraft and on the performance of candidate sensors.

A sensor system which meets the necessary performance requirements must be developed and evaluated, including the integration of appropriate data from a number of potential sources both on the aircraft and on the ground.

Finally, flight management systems and crew procedures must be developed which provide the pilot with the information required to allow avoidance in a timely manner.

The NASA program addresses each of these three major elements or three major areas, and I will briefly describe our efforts in each this afternoon.

First, in the area of characterization of the hazard, NASA has recently developed a high-fidelity hazard characterization model which allows study of the characteristics of convective wind shear phenomena such as microburst. It includes all the physical processes which have an impact on sensor performance, such as moisture content, thermal gradients, et cetera.

The model has been validated and published and is currently being used by NASA for safety-related studies of aircraft performance, sensor performance, and crew procedures. Relevant computer programs and data have been prepared and disseminated to the industry, and these will be used by the industry to evaluate candidate sensor systems, thus providing a common basis for comparison.

In the area of heavy rain aerodynamics, we have conducted wind tunnel tests in simulated rain which indicate relatively high potential degradation in aerodynamic performance of the airplane. But, in order to fully understand the impact on aircraft performance, we plan to conduct full-scale tests at our Langley Research Center following completion of the test facility later this year.

In the second major area of our program, sensor technology, there are several candidates with attendant strengths and weaknesses. The general requirements which must be met include operation in both wet and dry conditions, adequate resolution, and a thirty-to-sixty-second advance warning time. The candidates we are looking at, radar and LIDAR, LIDAR being "Light Detection and Ranging", appear the most promising to us for near-term application.

First, in the area of Doppler radar, feasibility was established in 1982 flight tests conducted also at NASA Langley. In these tests, airspeed compensation was introduced to remove the effects of Doppler shift caused by aircraft motion. The radar performed well in rain, but not so well in dry conditions. One of the major remaining problems to be solved is suppression of the ground clutter in an airborne system looking down at the ground. Potential solutions are currently being developed by analytically modeling the airport clutter environment and by collection and analysis of real, moving ground clutter data.

Based on these results, a set of detailed requirements for a Doppler radar system will be generated in late 1989 Candidate prototype Doppler radar designs will subsequently be evaluated which will, hopefully, lead to the development of a research Doppler radar scatterometer instrument, just a subcomponent for use in conducting ground and flight experiments. Assuming positive results, we expect that flight experiments will be conducted in late 1991.

In the second sensor area, LIDAR, major progress has been made in the last eight years in the use of Doppler LIDAR for measuring wind velocity, both from the ground and from the air. Major developers and users of this technology include the British Royal Signals and Radar Establishment, Lockheed Corporation, the National Oceanic and Atmospheric Administration, and NASA.

The major problems to be overcome in LIDAR include performance in rain, hardware complexity, and volume and power requirements. Lockheed Corporation, under contract to NASA, is conducting a performance and technology assessment for laser-based wind shear detection systems. The approach for this study parallels the NASA in-house Doppler radar study activities.

Upon completion of this study in mid-1988, a technology roadmap and future research requirements will be defined. Considering the fact that radar performs well in rain and LIDAR performs well under dry conditions, it is highly likely that the resulting airborne wind detection system of the future would be a hybrid of the two.

In the third area of our program which I will touch on very briefly, flight management systems, we are also doing work to determine what information is required by the pilot and what format the information is to be displayed to him for safe and timely avoidance of the wind shear hazard.

In summary, NASA is working closely with the FAA and has initiated a comprehensive research program to provide the necessary technology base for airborne detection, warning, and avoidance of low-altitude wind shear. While NASA's aeronautics research and technology program places major emphasis on new vehicle technology and the fundamental disciplines that underpin that, an important aspect of our program is the investigation of the phenomena critical to the safety of aircraft and the public.

NASA has a number of unique facilities and researchers with special skills to bring to bear on these safety-related issues. NASA's safety-related research is conducted in support of, and in very close cooperation with, the FAA which has primary responsibility for aircraft safety.

Thank you, Mr. Chairman. That concludes my statement. I would be glad to try to answer your questions.

Mr. OBERSTAR. Thank you very much for the technological assessment of the state of the art and review of the research that is underway, the studies that are being done, and the status of that research. I think that adds immeasurably to our fund of knowledge about the current state of weather detection and dissemination of information.

Dr. McCarthy, to do all of the detection required in isolating and identifying the wind shear microburst thunderstorm phenomena, how big a computer system is needed? What is required in terms of memory chips and logic systems? And is the computer capability available in the marketplace today, or is this something that is needed for the future?

Mr. McCARTHY. The answer to your question—let me answer the second question first. The answer is: Certainly, there is nothing overwhelming that isn't available off the shelf in terms of computational ability, in terms of processing the data. I really can't give you a number off the top of my head with regard to memory. A standard micro mini is more than adequate to process the data. The LLWAS is being processed on a rather small micro mini. So it's a non-issue.

What is a little bit more difficult is when we get into the area of expert systems approach to the microburst problem, and then we are getting into not so much memory as we are in simply how do we organize the information in a meaningful way. That is not a microchip issue as much as it is the strategy of how to proceed on the problem.

So for example, in Terminal Doppler, which is a system that has a number of algorithms that have to run very quickly and produce a single or several pieces of final information, we get into the strategy issue of how to sort through that information. That, to me, is where the issue is. But it's not an issue of fundamental computer capability as much as how to sort through very quickly the information that we want to bring to a controller or a pilot.

In that regard, we are making a lot of progress in identifying specifically the extraction of the critical information. But it's not a computer technology issue, but a strategy issue.

Mr. OBERSTAR. Well, that is very encouraging, because my concern with all the bits of information that need to be assembled, digested, and then transmitted, it occurred to me that there might be a need for very highly advanced, beyond the Cray computer into the supercomputer. That's fine.

So you have the hardware platform on which to develop these detection systems and make analysis and provide that information now. The question is, is the LLWAS system, is the NEXRAD or the Terminal Doppler radar system one that is adaptable for the future? Is the FAA acquiring a system that is expandable and that will be adaptable to future technology, to future software, or are we buying something that may be outmoded in a relatively short period of time before we're ready to put onstream?

Mr. MCCARTHY. Mr. Chairman, that is a very excellent question, and it is critical. For example, in the NEXRAD procurement, it is my understanding that the system is designed in such a way as to accommodate ongoing software development. The field is moving very rapidly, as I think you are very well aware, and in the NEXRAD program it is my understanding that there is built into it an evolutionary development capability which will incorporate new and expandable concepts.

The Terminal Doppler program is still in its very early development stage. It is critical that that same aspect be continued. For example, for the work that we're doing at NCAR and at MIT Lincoln Laboratory, we are looking at a whole series of advanced products that go five or six years down the line, that incorporate new concepts that will have to be programmed into a TDWR in subsequent stages.

So the answer to your question is the intent is certainly there, and in the procurement I am certain it will be there although all aspects of that have not been established. It is critical that it is.

In terms of LLWAS, I don't see that. I see some enhancements now, but I don't see it as an ongoing evolutionary system. I see still LLWAS as rather interim until the Doppler program comes up full steam. So I don't see it in the same category as Doppler, in the sense that it doesn't have years of enhancements ahead of it.

Mr. OBERSTAR. What about the investment that will have been made in LLWAS when the next generation of equipment is available, has been tested, has been proven out? Will the investment in LLWAS have to be discarded, or can that serve as a platform adaptable to new technology?

Mr. MCCARTHY. Again, I don't want to be part of the "Flat Earth Society" here as far as what you do with the LLWAS down the road. I don't see it as having the in-depth capability in the intermediate and distant future.

Mr. OBERSTAR. So to be realistic about acquiring something that is, as you described it, an interim system?

Mr. MCCARTHY. Yes. The other thing that you can do is that it has a certain level of capability of detection, and I think it's going to reach that level and then it's going presumably to stop at that point. Now, rather than decommission that system down the road, you may very well want to put that system at the second two hundred airports to give it some capability, given that we have the system capability.

I am not sure, by the way, that that is necessarily the right thing to do, because in a future airport system which may have both LLWAS and TDWR, both systems provide valuable information. But again, I don't see the technology in LLWAS going beyond a certain limited period that's not very far ahead of us.

Mr. OBERSTAR. Yes. Well, we recognize that there is that limited period of time which LLWAS will be effective. In the FAA's planning for the future, do you know if they are considering moving that system to the second tier two hundred airports or so?

Mr. McCARTHY. I don't believe the decision has been made. I think both ideas have been considered: leaving it at airports that currently have it and supplement TDWR with it, or perhaps moving it to the second tier. But that is a question to ask later on.

Mr. OBERSTAR. We will certainly do that.

Mr. McCARTHY. I don't think that decision has been made; and you can argue it both ways, technically.

Mr. OBERSTAR. The Chair will at this point recognize the gentleman from Pennsylvania.

Mr. CLINGER. Thank you, Mr. Chairman.

Mr. Rosen, what is the relationship between forward-looking airborne wind shear alert systems and the ground-based systems currently in place or under development?

Mr. ROSEN. Well, in the simplest terms, the forward-looking radar on the airplane would scan the flight path immediately ahead of the aircraft, within a five-to-fifteen-degree sector, the air and weather that he, the pilot, is going to be flying through in the next few minutes. The ground radar, as I understand it, has to cover the entire hemispherical spectrum around the airport. Therefore, both the resolution of the data is different, and the availability of it in a timely way to the pilot is different.

Mr. CLINGER. Is the technology basically the same, or are we talking about different types of technology?

Mr. ROSEN. In part, it is similar, yes. Obviously, the power and density requirements for packaging it on an airplane are much more stringent than ground-based systems both for the antenna and the support systems.

Mr. CLINGER. Are we going to end up using one or the other but not both? Is there going to be a redundancy factor here or will we be using both systems, both the land-based and the air-based?

Mr. ROSEN. I can give you a view. My view is that we will ultimately evolve to a system that fuses broad ground-based data into the airplane through a data link with real-time data available from onboard systems that can operate in wet and dry, and give the pilot a condensation of that information that allows him to react to the weather situation, as Dr. McCarthy said.

Mr. CLINGER. So he would be using both inputs; that is, the input from the ground as well as what he's got on the plane?

Mr. ROSEN. What the pilot sees would be the result of both. He would not see both. There would have to be a certain amount of expert systems, or artificial intelligence built in to fuse the data, pull the relevant data out, and portray it to the pilot in the appropriate form.

Mr. CLINGER. Can you give us any idea of how much time the pilot needs in order to have useful information? At what point does the information become useless to him because he doesn't have time to react?

Mr. ROSEN. It only becomes useless after he has had an accident, I would believe. I mean, anything that gives him forward-looking data with seconds, tens of seconds, or minutes of leadtime, is useful. The further away, the more useful it is, obviously.

Mr. CLINGER. Dr. McCarthy, would you like to comment?

Mr. MCCARTHY. Well, I would, for the most part, echo what Mr. Rosen has said. I think one point is that the name of the game here in the intermediate and distant future is integrating all sources of information and coming up with an artificially intelligent condensation of that in a useful way.

So I strongly agree with that. That's where we're headed. The integrated look at the problem is to integrate all sources of information. I think a minimum of thirty seconds to a minute is what we are really looking at for advanced warning, particularly from an airborne system. And, hopefully, from the ground-based system that looks at the whole area, something up to five minutes would be even better, so that you can really adjust. You don't want the whole thing to be entirely reactive. If we can get a better handle on the hazard in, for example, a five-minute period, we can really deal with that hazard, as severe as it is, in a more orderly fashion. So I think that's what we are really aiming for.

Mr. CLINGER. With sufficient advance notice of seconds or minutes you can avoid a wind shear problem? In other words, a normal wind shear would not cover such an enormous amount of geography that you would not be able to avoid it?

Mr. MCCARTHY. Generally speaking, that's correct. And of course, if the encounter is below a thousand feet, or particularly below five hundred feet, that's when you're really in big trouble. So by getting a minute or two advance warning, why, you may end up going through the shear but not at an altitude that is critical or if you're considering a takeoff then you will delay takeoff.

Mr. CLINGER. I understand.

Mr. Rosen, does airframe design or configuration have any relationship to an airplane's ability to withstand a wind shear encounter, and has NASA done any research in this area?

Mr. ROSEN. It certainly does. I am not aware of any research that has been done specifically to look at the vulnerability of particular aircraft designs to wind shear. But it certainly does have an impact.

Mr. CLINGER. Thank you.

Thank you, Mr. Chairman.

Mr. OBERSTAR. Dr. McCarthy, in your testimony on page 3 you refer to a promise of wind shear warning prior to the phenomenon, speaking about Terminal Doppler weather radar, and point forecasting of thunderstorm activity. You know, thunderstorms are far more widespread a phenomenon and are far more significant because they cover such wide areas and they are major weather systems and within them, of course, are the wind shear and the microburst.

How far along are we with technology in advance detection both of thunderstorm activity in localized area and in advance wind shear warning in real time to pilots?

Mr. McCarthy. Okay. Again I will answer the second question first. With regard to microbursts, there are about three features aloft that are associated with the formation of a microburst as observed from a ground-based system. One is, as a microburst hits the ground, it spreads out and diverges at the surface. That is easily detectable. Likewise, aloft at about roughly three miles altitude, air is coming together and that is detectable by Doppler radar. So the first thing is convergence of air aloft.

Many microbursts rotate as they descend, similar, in a sense, to a tornado, although it's a different phenomenon. That rotation is detectable by Doppler radar.

Finally, we can see the precipitation descending with a very sensitive Doppler radar. In fact, it need not be Doppler. We're looking at the reflectivity channel. The combination of those three observations gives us or is beginning to give us a substantial confidence that we can see the microburst in its formative stages.

I don't think we will get to the point where it's a hundred percent, by any means, but it will give us, in my view, with a couple of more years of the work that we're doing now, a substantial confidence that we are seeing the microburst in its formational stages. That would end up showing up on a controller display, for example, as a flashing display which would say "Microburst descending," or it may turn out to be a product such as "Microburst expected one mile final in three minutes." That is the kind of thing we're looking for. But we still have some work to do to demonstrate that.

Now, the first question, concerning the formation and evolution of thunderstorms, at NCAR, where I work, and also at NOAA, the NOAA program called PROFS has been doing a great deal of work in looking with not only Doppler radar but with satellites and other surface measurement systems at how the weather is organizing itself in the next thirty to ninety minutes. There is a great deal of optimism that we can anticipate in a selected area such as a metropolitan terminal area where certain things are going to happen, when the wind is going to shift, where a thunderstorm is going to form, how it's going to move, is it going to be severe, et cetera.

I would say that in a time scale in the two-to-four-year period from now, these enhanced products in the terminal area will become available. But I don't want to promise them without telling you that there is a substantial amount of development that still is required. Then we must test them in a working environment to see how beneficial they are.

But I have a lot of optimism that these enhancements will make a big difference in how we deal with hazardous weather not only for safety, but the efficiency. For example, everybody got nailed by thunderstorms in the Washington area last Friday evening. If you can anticipate that, the ability to handle air traffic would be substantially enhanced if those products prove as good as I think they will.

Mr. OBERSTAR. I think that's the point we are looking at, the anticipation of this localized phenomenon that you call point forecasting, so that in that half-hour to hour-and-a-half period prior to takeoff the airport and the pilot knows—or prior to landing—knows what the weather system is going to be, and then within that weather system, further anticipation of unique systems or unique phenomena can make a great deal of difference in a person's day in a pilot's decisionmaking process.

So, carry on with that work. It's very important.

Mr. MCCARTHY. Well, it's very exciting, and I think we will do that.

Mr. OBERSTAR. Yes, it certainly is.

Dr. Rowland?

Mr. ROWLAND. Thank you, Mr. Chairman.

Just let me follow up on that last question and comment about last Friday. I think most everyone that was trying to leave Washington and trying to go somewhere else was caught up in that situation. Do I understand that if we get the Terminal Doppler radar developed the way that we want it, that we might be able to let planes depart and arrive even in situations like we had last Friday with thunderstorms all around?

Mr. MCCARTHY. Well, I am only reflecting on what I heard about last Friday because I don't know the details.

Mr. ROWLAND. Last Friday was pretty bad.

Mr. MCCARTHY. Okay. I don't want to get the point misconstrued. I think that the initial purpose of Terminal Doppler is to identify hazardous low-altitude windshear and, again, to pass that information to pilots so they can make a decision, an appropriate decision, to, in my view, avoid those kinds of conditions.

As we continue to develop that terminal weather capability, then I think we can define the hazards more explicitly and deal more effectively with them. Now, if we know that the hazard is there in a generic sense, there is a tendency to shut down. On the other side of the coin, you don't want to use this technology to make the margin so tight that people take chances.

So safety is our first objective, but a second important and economically viable objective is to improve the efficiency of the airflow, the air traffic flow. I think that is an objective of the system once we demonstrate that these kinds of capabilities are there.

I don't know if that answers your question.

Mr. ROWLAND. It does.

Mr. MCCARTHY. I am not anxious to go zipping off between two severe thunderstorms just because I have a Doppler radar looking at it.

Mr. ROWLAND. Right. You need to know where to draw the line, even in advanced technology like we might have.

You were talking about the ability of this system to detect the formation of a microburst. Do we now have the capability of detecting the circumstances that create microburst, or will this Doppler radar help us do that? Do we do that now?

Mr. MCCARTHY. Well, of course, there are no operational Dopplers currently operating. We are testing some at Denver, and that has occurred at several other locations.

Again, the only system that I know about that will anticipate the actual microburst is Doppler radar. Now, we do have an understanding in the dry environment of those days on which those drier-type microbursts are likely to occur, and there are several reports that have been published now that would allow, for example, the National Weather Service to give an indication that, "Today is one of those days when we expect microburst." But that is a much more generic indicator, and it's only marginally useful. It doesn't say that there will be one, it's just that conditions are ripe for it.

Mr. ROWLAND. I am sorry that I missed your presentation earlier. But can these microbursts occur outside of a thunderstorm area?

Mr. McCARTHY. All microbursts occur in convective precipitation, but many of them, particularly in the western half of the United States, generally speaking, can occur in storms that are far less severe than thunderstorms. In fact, one of the big areas that we had to deal with is to let pilots realize that you don't need a thunderstorm to produce a microburst. If you go east, say, in the Washington area down to the humid southeast, essentially a hundred percent of them are in the vicinity of a thunderstorm. But that is not true in Denver, Tucson, Salt Lake, and Kansas City in the drier climates.

Mr. ROWLAND. Let me ask you something in a little different area. We've talked about the air controllers being overburdened now with what they have to do and the fact that they are part of the link in transmitting information to the pilot of the aircraft. Is it better for us to try to develop that system with direct communication to the aircraft from the detection equipment, or to try to get more air traffic controllers who have more meteorological experience to be involved in the link or not?

Mr. McCARTHY. Well, to answer the question, the fact is that we are currently producing a wind shear product now. It needs to be better, but there is no choice now but to use the controller as the link. Certainly, an uplink to the cockpit is extremely desirable, but I don't think that the controller link should ever be eliminated. The reason for that is that the presence of weather hazard is certainly a critical issue for the management of air traffic in the terminal area. So you certainly don't want to bypass the controllers. You certainly do want to minimize the delay to get the information to the pilot. And uplink to the cockpit is certainly the quickest way to do that.

But then, as Mr. Rosen said, we want to extract only that information which the pilot really has to have to make the appropriate decision. But I certainly don't see it as either-or. I think we have to have both for different reasons. In the short term, of course, we have no choice but to use the controller. But we need it both ways indefinitely, as far as I am concerned.

Mr. ROWLAND. I understand that one of the problems now is in getting information to the pilot in a context that is usable and there may be some problems with the computers or software—I don't know that much about computers—but some problems in getting the information to him.

Is it possible that that information from the controller could be computerized in just a split second, almost, and then transmitted to the pilot in a form that is usable to him?

Mr. McCarthy. I am not sure I really understand your question. If you're saying that you want to go to the controller first and then the pilot?

Mr. Rowland. Right.

Mr. McCarthy. I don't think that's a necessary stop on the way to the pilot once you establish what it is you want to send. So I don't see it—certainly, the computer can do things very quickly, but I don't see a particular need to stop at the controller again once you establish the veracity of what you're trying to send and the nature and how you display that information.

Mr. Rowland. I had understood that there was some problem about transmitting the information from the controller to the pilot, that there was a problem about software. Maybe that's not correct.

Mr. McCarthy. I am not aware of it. Again, that is part of the business I am not that involved in. So it may be that you are referring to something that I am not aware of.

Mr. Oberstar. I think that it may be fair to say that it's more a workload problem than a software problem.

Mr. Rowland. The Mode S transponder couldn't take the information from the controller in the form that it is transmitted now.

Mr. McCarthy. I would simply have to defer that question, too. Perhaps someone from the FAA could talk about that a little bit later. I am not aware of that.

Mr. Rowland. Thank you.

Thank you, Mr. Chairman.

Mr. Oberstar. In the course of your research work, have both of you involved user groups, pilots, airlines?

Mr. Rosen. Well, I think I mentioned in my testimony that we have been involved with industry. That has been principally the manufacturers, both of aircraft and of avionics systems. We do get involved in the course of the aeronautics research program with users in our human factors program, for example, which looks at the interface between the crew and the cockpit. The human factors or "soft science" side of the business is a very important part of our program and has a direct influence on how you would handle information related to wind shear or any other cockpit incident. So that is one aspect where we work very closely with the airlines and the pilots.

The remainder of the interaction is more with the industry and the manufacturing side.

Mr. Oberstar. Dr. McCarthy.

Mr. McCarthy. User groups have been an extremely important part of my work in two jobs that I have been working on. One is basically the surface-based detection systems. The Operational User Group, which I referred to in the testimony, has been a very important advising process to identify how controllers and pilots want to see new information that they otherwise did not get or had not received previously. So that has been very important in driving the program.

Also, in the wind shear training aid development, which Mr. Kirchner is going to talk about later on this afternoon, we had a considerable number of what I would call users, pilots from a broad segment of particularly the commercial aviation area, playing a major role in the whole evolution of that program. I think it's such an important area that we, as scientists and engineers, unfortunately have too frequently forgotten. It is such an important part of the work.

Mr. OBERSTAR. I fully agree. The reason I raise the question is because I think it's so important that we involve pilots and controllers, not just the supervisory level folks and the management people in the airlines or in the FAA, but those who are the working level, to see what are the problems and how do you adapt this technology to the need of the controller and the need of the pilot and the communication between the two. That is the critical point. All that great information is not going to benefit the cause of safety if the controller can't use it or can't transmit it to the pilot who can't use it or get it in timely fashion. So your work involving them I think is very important.

Mr. MCCARTHY. Just as an example, we had a controller from Charlotte tower in one of our groups, and I will never forget the meeting that we had in which he was so active in saying, "That's crazy. That's something we couldn't possibly use, but let's try this, this, and this." It was just an amazing experience to get that kind of user feedback. That has really helped drive some of the products that we have been working with. It's so important.

Mr. OBERSTAR. In the same vein, you suggest, as do all the witnesses, an improved and advanced pilot training preparation for recognizing wind shear and microburst when you get into them. How effective in that regard are simulators for a training device?

Mr. ROSEN. Well, I will be glad to comment on that. It is only as good as your ability to model the wind shear and its effect on the airplane. If you can appropriately model the microburst or the wind shear phenomena and its impact on the performance of the airplane, then it's very good in terms of what the pilot encounters in a microburst situation. I think we've done that very well. There is certainly more that needs to be done there, but it has been an important training aid, and I am sure Mark Kirchner can comment on this further in terms of how pilots react when they get in a wind shear phenomenon.

Mr. OBERSTAR. It seems to me that apart from putting pilots in the situation, which you can't do with a weather phenomenon——

Mr. MCCARTHY. That's right.

Mr. OBERSTAR.The next best is a simulator where those events can be recreated to some extent. But I am glad to hear your response.

You have done a good deal of research on the nature of wind shear and the events that lead up to it, as you described and showed in the slides. What are the principal precursors of wind shear and can they be identified by current technology or technology that is in testing?

Mr. MCCARTHY. Do you mean by precursor something like one, two, three hours ahead of time, or are you talking about one, two, or three minutes ahead of time?

Mr. OBERSTAR. I am talking about longer-term, two hours ahead of time, three hours ahead of time.

Mr. McCarthy. Well, I mentioned previously that in the dry environment such as in the west, the precursors to the formation of microbursts are, one, the expectation of convective storms. So you've got to have that kind of day. We also need moisture at mid levels, around 18,000 feet or so. We also need pretty dry air in the lower altitudes near the ground. The reason for this is simple. If a storm is produced and a rainshaft starts descending from, say, mid levels, around 18,000 feet, and that rain falls into the dry air, the evaporation associated with the rain falling in dry air produces cooling, which causes the air to plunge.

So in the dry environment we have a pretty darned good understanding of the precursors. We can't say specifically that one particular microburst will form at such a location, but that is the basis for coming up with, say, a microburst forecast for the day.

In the humid area, we simply know that if there are thunderstorms, expect microbursts, but that's about all we can do.

There are lots of other wind shears besides microbursts, such as frontal shears, shears associated with cold fronts, with warm fronts, with cyclonic storm systems. These are all predictable many hours in advance. There are also shears associated with terrain-induced shears, such as downslope windstorms, descent of cold air down a mountainside. These are also rather predictable. They are also probably less severe, although some would argue with me on that.

So some of the other kinds of shears are routinely forecast, and the National Weather Service puts these into the area forecasts, terminal forecasts, when these types of shears are well known.

Mr. Oberstar. The National Weather Service then can provide the longer-term—two or three hour or longer—advance indication of thunderstorm activity which may include wind shear, and you would rely on that rather than on the Doppler weather radar system?

Mr. McCarthy. Right. That's right. And that is routinely done now. And, of course, in our training program that Boeing and we have all been working on we emphasize those kinds of forecasts when wind shear is in the forecast or when thunderstorms are in the forecast, expect wind shear. And we are pushing that, and frankly the Weather Service is doing a very good job in those types of shear relationships.

Mr. Oberstar. I am trying to get an understanding of the limitations of technology. Is it realistic or not to anticipate that the Doppler system will be able accurately to measure headwind and tailwind?

Mr. McCarthy. Do you want to go ahead on that?

Mr. Rosen. That's your background.

Mr. McCarthy. Certainly, on the airborne system it's looking ahead and it will be looking at the headwind-tailwind component but not, for example, the vertical component. On a ground-based Doppler system, in the direction in which the radar is looking it will measure headwind-tailwind component. If it's looking at an angle other than where the airplane is flying, it's measuring another component of the wind.

So one of the limitations of ground-based Doppler is whether you can accurately portray in all cases the headwind-tailwind component. An important part of the research work going on at Denver and previously at Huntsville last summer is to identify what percentage of the headwind-tailwind component we are in fact measuring. To do that, by the way, we will be using at least two Doppler radars to always look at the microburst, to look at the asymmetrical component, and then eventually to verify how accurate a single Doppler measurement is.

So it is an important point and one that is garnering a great deal of attention in the development work that we are doing for the FAA.

Mr. OBERSTAR. Is radar siting a significant factor in the ability to detect weather systems?

Mr. McCARTHY. Absolutely. It's a big, big deal, in a number of ways.

Mr. OBERSTAR. Can you describe for us, then, where radar should be located ideally for the maximum detection?

Mr. McCARTHY. Okay. You're asking the right questions here for sure.

First of all, when a microburst—that's the target that we are after. That is, we think, the number one enemy—reaches the ground and spreads out, the depth of the outflow, as in some of the pictures that I showed you, is quite shallow. Given that the Earth is curved, if you get too far away from the event, the radar looks over at an altitude higher than the microburst is occurring.

So we really have to be within about fifteen or twenty kilometers, let's say, eight or ten miles of the airport, in order to effectively see the microburst at the airport. Otherwise, the microburst is below the radar horizon, or may be. So that is the first limitation.

The other issues regarding the location of the radar relate to two points that you have already raised, Mr. Chairman. The first is the runway component. Some would argue that putting the radar on the airport proper gives you the best estimate of runway component. Others would argue—and I am in the latter position—that by getting away from the airport a short distance and then looking not only over the airport at low altitude but above, we can get not only most of the runway component but we can see the descending microburst.

If you put the radar right on the airport, the one place you can't look with that radar is straight up because that's the cone of silence, essentially, the way the radar is scanned.

So we think the optimal location is a short distance off the airport so we can look above, watching the descending microburst, as well as detect the microburst on the surface. The most important thing that this system may give us is a precise estimate of runway component.

Mr. OBERSTAR. So it's fair to say, then, that the location of the radar is still a matter of some research and analysis yet of data, but you are close to getting a configuration, locational configuration that will give you the optimum measuring capability?

Mr. McCARTHY. Yes. And I think we are converging mostly to the off-airport short distance site. I think that is where the convergence is that we're coming to. But again, all members of the jury have not returned on that one. We think that's going to be it.

Mr. OBERSTAR. Is it likely that one Doppler system will be adequate, or as you seemed to be suggesting a moment ago, you may need two within the airport vicinity in order to pinpoint the essential information?

Mr. MCCARTHY. The game plan that we're working on is one Doppler. Of course, researchers like me would like three, because then you can resolve all components of motion associated with a storm, vertical and horizontal. I have a high degree of confidence that the job can be done adequately with one radar, although two would be slightly better because we would resolve the last ambiguity associated with it.

Mr. OBERSTAR. Would two give you greater likelihood of detecting asymmetrical microbursts?

Mr. MCCARTHY. Certainly. No question about it.

Mr. OBERSTAR. Isn't that a very significant factor, of being able to detect that additional dimension?

Mr. MCCARTHY. Well, it's a factor. I think that when all is said and done, it will turn out to be a relatively minor factor. Again, I was referring to that a moment ago when we talked about runway component because if all microbursts were symmetrical, then the issue of runway component would be a non-issue because any way you looked at it, you would get the runway component.

It's an issue. We have not fully resolved it. We think, based on the work we've done so far, that there are ways to come up with a sufficiently accurate estimate of runway component for any direction, that I think that the critical success of the product will be definitely high enough with a single Doppler radar. But I can't sit here and say that it's absolutely resolved. But the directions that we're going in suggest that it will be resolved.

Mr. OBERSTAR. Thinking back now on these technical complexities, earlier in your testimony you suggested that possibly two to four years would be a time frame for having Doppler radar onstream and operational. Doesn't that seem a little ambitious? Or am I reading more complexity into your responses than is reasonable?

Mr. MCCARTHY. Not recognizing exactly when I made the statement, and looking at the calendar, I am not sure what I am getting into here.

Mr. OBERSTAR. I don't want you to be in the position of a seer, you know.

Mr. MCCARTHY. Okay.

Mr. OBERSTAR. But given your best engineering judgment, your best technological estimate of where we are and the problems to be overcome, what is the time frame that we're talking about? I am not asking you to give us costs, but we have to know something about what it takes to get to that point in time.

Mr. MCCARTHY. Sure. In terms of the detection of a microburst at a low altitude over an airport, my estimate is by the end of next summer the fundamental technology will be operationally demonstrated to a high degree of confidence. We are—I got kind of rushed there right before the break—but in the last thirty days we have detected one hundred seventy microbursts within thirty kilometers of the radar at Denver.

Mr. OBERSTAR. I see.

Mr. McCarthy. The numbers on the detectability of those microbursts are still being reviewed. I can only say that I am not even cautiously optimistic, I am quite optimistic that we are doing a very good job of detecting the event at the surface.

The uncertainties are in two areas, in my opinion. The microburst aloft, which is an enhancement, and I would say that is another year or two to be demonstrated before we are confident in that. And finally, the only other area of uncertainty is whether we're going to look at seventy percent of the runway component or ninety percent of the runway component. That is where I think the areas of uncertainty are.

So except for those two uncertainties, by the end of next summer I am quite optimistic that the fundamental demonstration will be complete.

Now, beyond that are these enhancements. And I am going to say something like two additional years for the product aloft, and another year or two after that the convection initiation, thunderstorm initiation product will be coming along. So there is a lot of confidence there.

Another product that we expect to demonstrate, I think quite successfully next summer, is the windshift phenomenon; that is, where is the windshift and when is it going to pass the airport. Now, that is not a safety issue, but it sure is a runway configuration issue. I passed over it very lightly earlier.

So, two to four years, and we are off doing something else. That's the way I look at it.

Mr. Oberstar. Well, that is certainly very encouraging. And I hope you are right on target because I think the traveling public is anxious to see progress made and technology applied to the resolution of this very, very baffling and frightening, in some respects, phenomenon.

Mr. Oberstar. Thank you, Dr. McCarthy, and you, Mr. Rosen, for being with us today. Thank you very, very much for your very enlightening testimony, and carry on with the good work.

Mr. McCarthy. Thank you, Mr. Chairman.

Mr. Rosen. Thank you.

[The prepared statements of Mr. McCarthy and Mr. Rosen follow:]

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TESTIMONY OF JOHN MCCARTHY, PH.D.
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
BEFORE THE
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT
HOUSE COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION
WASHINGTON, D. C.
JUNE 30, 1987

My name is John McCarthy, and I am the manager of the Research Applications Program at the National Center for Atmospheric Research, called NCAR, located in Boulder, Colorado. As part of this position, I direct low-altitude wind shear research and have approximately thirty employees engaged principally in this activity.

It is a pleasure to provide this committee with an update on low-altitude wind shear activities that are pertinent to the mitigation of this most severe aviation hazard. As you know, I have been deeply involved with identification of the scientific nature of the hazard, particularly the convective microburst form of wind shear, for approximately ten years.

The Chairman of the National Transportation Safety Board has recently been quoted as saying that wind shear is the single most hazardous weather situation responsible for causing the greatest loss of air carrier passenger lives in the United States. Fortunately, in my opinion, the Federal Aviation Administration, in conjunction with other federal agencies, the private sector, and academic institutions, has developed a rather complete plan to mitigate the wind shear threat. Several key elements are far along toward completion at this time.

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LOW-LEVEL WIND SHEAR ALERT SYSTEM ENHANCEMENTS

The only operational ground-based wind shear detection is the Low-Level Wind Shear Alert System. It is now operational at approximately 90 airports. While the system was designed to detect simple wind shifts, especially gust fronts, I consider the current six-station LLWAS system inadequate for detecting the most serious wind shear threat, the convective microburst. This is due to its crude detection resolution, its rather archaic detection computer software, and to a rather confusing controller display capability.

Following several years of development work to improve the LLWAS system after our analysis of the system during the Joint Airport Weather Studies Project in 1982, we are assisting the FAA in field testing a new system as a prototype enhanced system. This new system will include a 12-station network, improved microburst and gust front detection algorithms, a radically improved runway-oriented display, and controller/pilot hazard alert message. Full demonstration testing is scheduled to begin July, 1987 at Denver.

Finally, I do not consider even the enhanced LLWAS system to be other than a partial solution to the low-altitude wind shear problem. There are a number of limitations associated with the system; however, given that the basic framework for this system is currently at a large number of airports, the FAA should maximize its capabilities as one of a variety of simultaneous solutions to the wind shear hazard.

OPERATIONAL USER GROUP

Our work for the FAA at NCAR has well examined the scientific basis of the low-altitude wind shear threat to aviation. However, to incorporate the aviation system user, namely pilots and controllers, into the process of identifying the hazard in an operationally useful manner, we have become deeply involved in a process of transferring our scientific work into applications. A particularly important part of the LLWAS enhancement concentrated on the formation of the Operational User Group. This group consists of pilots from the commercial and general aviation sector, air traffic controllers, and scientist/engineering technical providers. They have met several times to provide advice on determining what aviation system users require in terms of quantitative severe hazard warnings, in order to make safer avoidance decisions. The upcoming test of the enhanced LLWAS at Denver will focus on a runway-oriented wind shear alert message, derived from these User Group considerations. In addition to implementation in the LLWAS, User Group input will be addressed in the development of Terminal Doppler Weather Radar products.

TERMINAL DOPPLER WEATHER RADAR PROGRAM

Under sponsorship of the FAA and in conjunction primarily with MIT Lincoln Laboratory, I direct the NCAR portion of an effort to develop a prototype automatic detection and warning system to warn pilots and controllers of the presence of a number of airport terminal area severe weather hazards, particularly severe low-altitude wind shear. The effort includes algorithm development (with artificial intelligence), verification of algorithm quality during a field test at Denver in 1987, the development of suitable air traffic control tower displays, formulation of appropriate warning messages to pilots, and a full operational demonstration of the system planned for Denver in the summer of 1988. This effort leads the FAA procurement of Terminal NEXRAD and Terminal Doppler Weather Radar systems, which are expected to be deployed in 1990 and 1993, respectively. It is my understanding that Terminal NEXRAD Doppler radars will be deployed starting in 1990 at 17 major hub airports. It is my further understanding that approximately 100 Terminal Doppler Radar Weather Radar units will be procured and deployed starting around 1993.

Features of TDWR that offer major advantages over other systems include the significant promise of wind shear warning prior to the phenomenon actually striking the ground and a much better measurement system resolution.

I consider it critical that the FAA continue to develop and deploy these Doppler radar systems for the major airports in the U.S. While not even Doppler radar can solve all wind shear problems, these systems represent a vital capability that can greatly improve the safety of the flying public.

CONVECTION INITIATION AND DOWNBURST EXPERIMENT

With funding from the National Science Foundation, the National Oceanic and Atmospheric Administration/Environmental Research Laboratory, and the FAA, NCAR will be coordinating a research experiment at Denver during the summer of 1987 to examine the ways in which thunderstorms can be point forecast, primarily using meteorological Doppler radar. This concept was an outgrowth of the Classify, Locate, and Avoid Wind Shear experiment in 1984, when we found that we could forecast a particular thunderstorm occurrence with respect to an airport, with approximately a 30 to 90 minute lead time. A futuristic example of a convection initiation-derived thunderstorm forecast might be: A thunderstorm is expected to form 2 miles west of Denver Stapleton International Airport in 45 minutes, or at 1535 MDT, and move to the east at 15 miles per hour.

Such a thunderstorm point forecast technique is in contrast to today's technology, which can only provide a general indication that a thunderstorm is possible over a general geographic area in a rather vague time period (for example: there is a 20% probability of thunderstorms in the Washington, D. C. area from early afternoon through early evening). The implications of this technique, when fully matured, will be to help mitigate the deleterious effect of thunderstorms on airport capacity and delay issues.

In addition to the convection initiation work, we will further examine the features aloft associated with microburst wind shear, in an effort to fine-tune our algorithm developments for TDWR. The intention is to develop greater confidence that a microburst is actually forming above the airport area. This undertaking may lead to descending microburst forecasts and provide advanced warnings for these most serious of aviation hazards.

PILOT WIND SHEAR AWARENESS AND TRAINING

I was fortunate to be the meteorologist member of the Boeing-led Federal Aviation Administration Wind Shear Training Aid program. This in-depth training syllabus was recently distributed to all commercial airline companies, in an effort to provide a much improved wind shear training to commercial pilots.

The concept focuses on the critical need for pilots to make more timely severe wind shear avoidance decisions and to provide pilots with a wind shear recovery technique that can often allow for a safe exit from some wind shear conditions.

In my view, it is critical for all pilots to receive improved wind shear training. While the FAA Wind Shear Training Aid addresses the needs of commercial airline pilots, there remains a major breach in critical knowledge transfer to the remainder of the piloting community, especially among business and private pilots. I recommend that a very high priority be placed on continuing the pilot wind shear training technology transfer process to the remainder of the community. I, therefore, strongly endorse the FAA Advanced Notice of Proposed Rule Making that, if it continues to an actual rule, will require advanced wind shear training. The process of establishing this rule must be continued with all deliberate speed. Transferring this to the pilot remains the first and most immediate priority to enhance safety.

CONCLUSION

We have made rather extraordinary advances in low-altitude wind shear technology development over the past several years. The LLWAS is currently undergoing testing of an enhanced version that can provide some improvement, although it will always be far short of a complete solution. The Terminal Doppler Weather Radar effort is rapidly advancing the technology of an automatic detection and warning of the low-altitude wind shear hazard. Pilot awareness and recovery training has recently taken an advanced leap with the FAA Wind Shear Training Aid; this transfer must be extended to other parts of the pilot community.

It is critical that congressional pressure be maintained to effect a complete solution to the wind shear threat. Please remember that THERE IS NO SINGLE SOLUTION TO THE LOW-ALTITUDE WIND SHEAR PROBLEM!

The FAA has recently published the *Integrated Wind Shear Plan*, which outlines what I consider to be a complete description of a total solution to the wind shear threat. This document is, in part, a response to the National Research Council study entitled *Low-Altitude Wind Shear and Its Hazard to Aviation*. The combination of these two efforts well substantiates the steps that the FAA must follow to effect a long term and balanced attack on the wind shear threat. As long as the federal government, in conjunction with the aviation industry, continues to press for this complete program, there is considerable optimism that we will see low-altitude wind shear accidents with much less frequency. Perhaps instead of the current accident rate of once each 12 to 18 months, accidents will be relegated to once every 20 to 30 years. It is critical that Congress keep pressure on the system to complete the necessary response to this most serious of threats to public safety.

NASA
National Aeronautics and
Space Administration

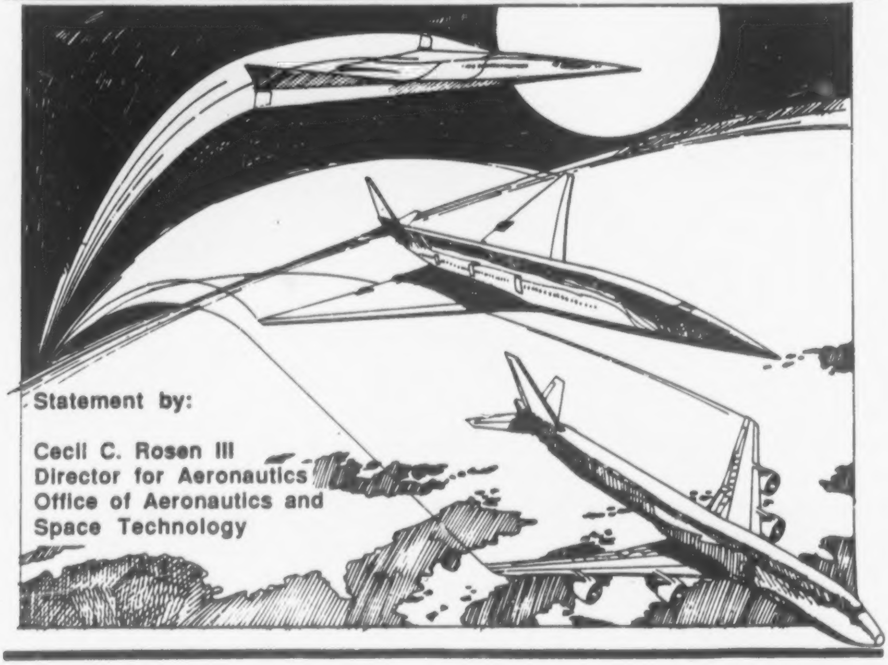
Hold for Release Until
Presented by Witness

June 30, 1987

Subcommittee on Investigations and Oversight

Committee on Public Works and Transportation

House of Representatives



Statement by:

Cecil C. Rosen III
Director for Aeronautics
Office of Aeronautics and
Space Technology

100th Congress

STATEMENT

OF

Mr. Cecil C. Rosen, III
Director for Aeronautics
Office of Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Investigations and Oversight
Committee on Public Works and Transportation
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I appreciate this opportunity to discuss with you NASA's research activities in the area of wind shear detection and avoidance. Low-altitude wind shear is widely recognized as a major hazard to aircraft. In the United States, during the period 1964 to 1985, there were at least 26 civil transport accidents and 3 incidents involving 500 fatalities and over 200 injuries for which wind shear was a contributing factor. Numerous methods of reducing the low-altitude wind shear hazard have been proposed by the airlines, airframe manufacturers, and the government. The Federal Aviation Administration (FAA), as lead agency for civil aviation safety, has established an integrated wind shear program plan which addresses the wind shear problem through focused research and development efforts encompassing training, ground-based sensors, terminal information systems, and airborne detection and avoidance systems. In July 1986, NASA signed a memorandum of agreement with the FAA to pursue a cooperative research program in airborne wind shear detection and avoidance. The objective of this program, which spans five years, is to provide industry with the engineering data base necessary to develop a certificable airborne wind shear detection system.

Today I will describe the key elements of the NASA wind shear research efforts. The primary element is the development of forward-looking wind shear sensors for aircraft which can improve the flight crew's ability to reliably detect and avoid hazardous wind shear. Other elements of the program include characterization and evaluation of the wind shear hazard, establishing airborne wind shear detection system requirements, consideration of pilot/human factors, and determination of heavy rain effects on the sensor's ability to detect wind shear and on aircraft performance.

Over the past several years, FAA and NASA have been developing a program on wind shear which builds on and focuses ongoing activities related to this problem. The National Oceanic and Atmospheric Administration (NOAA), civil transport manufacturers, avionics manufacturers and the airlines have also been involved in attempting to better understand, detect, avoid, and survive encounters with severe wind shear. One of the recommendations of the 1983 report on "Low Altitude Wind Shear and Its Hazard to Aviation" by the National Research Council was that research should continue on the use of airborne sensors as a means for detecting low-altitude wind shear. The main advantage of an airborne system is that the equipped aircraft would have the systems capability at all airports at which it operated, rather than only at the airports equipped with a ground-based system. It is generally recognized, however, that an airborne forward-looking system poses more difficult technical problems and has a higher associated development risk than a ground-based system due to the fact that the sensor is on a moving vehicle. Additional problems which must be solved include ground clutter and rain attenuation. A primary requirement for airborne forward- looking sensors is that they perform in heavy precipitation as well as in clear air. Although there is no assurance that a practical airborne forward-looking system capable of detecting both wet and dry severe wind shear "microbursts" can be achieved, the high potential payoff of such a system and the encouraging results of initial efforts warrant a serious and concerted research effort in this area.

The airborne sensor will be used in the approach phase of flight. The sensor performance requirements will vary as the aircraft approaches touchdown. During the transition from the enroute flight to the final approach fix, the flight crew will have the ability to maneuver the aircraft. During this phase of flight, areas along the intended flight path will be scanned, as well as areas within the horizontal maneuverability envelope (determined according to the aircraft performance). The emphasis is on the detection of hazards occurring along the flight path. Whenever a hazard is detected, the flight crew is alerted and alternate, safe flight paths are communicated to the crew. If no safe path is found, then the crew is warned, evasive maneuvers are suggested, and Air Traffic Control (ATC) is advised. During this phase of flight, the area of concern for the forward-looking sensor is about 60 to 120 seconds ahead of the aircraft, and horizontally to an angle that is within the maneuverability of the aircraft. Once the final approach fix has been reached, forward-looking sensors have to tightly scan the intended flight path and warn the flight crew if hazardous wind is encountered. During this phase of flight, the area of concern for the forward-looking sensor is from 10 to 60 seconds ahead of the aircraft. Another task to be accomplished is to determine the necessary information and display formats required for the flight crew to avoid the wind shear or initiate the necessary maneuvers to recover from a wind shear encounter. This will allow areas of concern to be specified more accurately.

Based on preliminary tests and studies conducted by the industry and government, radar, laser, infrared, and acoustic sensors have demonstrated the capability to predict the occurrence of wind shear to some degree. Currently, the NASA program is concentrating on radar and laser sensors which appear most promising for near-term application. Each of these sensor concepts has advantages and disadvantages. Radar has been tested in a research configuration for detecting wind shear and in an operational environment for detecting turbulence. The radar's ability to detect wind shear in an operational environment has yet to be demonstrated. Detecting winds in a high ground clutter environment on a moving platform complicates the issue. The radar's ability to operate in rain is very good. In optically clear air, radar performance is not as promising. Conversely, the performance of lasers onboard research aircraft has been very good in optically clear air, but poor in heavy rain. Laser eye safety standards may preclude using lasers of adequate power for suitable forward-looking range performance to detect hazardous wind shear in time for a flight crew to safely avoid a hazardous area. Infrared radiometer techniques have been used to detect temperature changes that are associated with some wind shear, but their reliability as a wind shear detector remains to be determined. A mix of airborne sensors may be required to provide the proper operationally acceptable detection and avoidance system for wind shear under all meteorological conditions. Development of an operational system will require a well-coordinated industry/government interaction to achieve the requisite technologies and assure early acceptance by the aviation community.

A critical element of the wind shear detection and avoidance program is an advanced high resolution, numerical wind shear model which has been developed at the NASA Langley Research Center. It incorporates a newly developed cloud scale model which allows study of the physical and dynamic characteristics of convective wind shear phenomena such as microbursts. The wind shear model, which includes all of the phenomenology that impacts performance of candidate sensors, has been validated and reports published. Relevant computer programs and data needed by the industry have been prepared and disseminated. A flight path deterioration parameter which can be supported with remote or present position information has been developed. System concepts based on this parameter have been identified and are currently being evaluated.

An airborne wind shear experiment was conducted by the NASA Langley Research Center in 1982 using a research Doppler weather radar mounted in a Skyvan aircraft. Wind radial velocity measurements were made from rain cell signals while flying in the vicinity of severe thunderstorms. The flight experiment verified the feasibility for making airborne wind velocity measurements in which air speed compensation was incorporated to remove the ambiguous effects caused by aircraft motion. Alternative radar designs are being studied using analytical techniques and a sophisticated radar/microburst simulation program. The problem of radar clutter signals backscattered from the ground environment around airports must also be defined and clutter models developed for use in the simulation program. An initial version of the radar simulation has been developed by NASA, incorporating wind field and reflectivity models of the microburst phenomenon and a preliminary map model of the clutter environment around airports. Work is continuing on expanding the features of the simulation program and the analysis of various radar configurations. A contracted effort with the Environmental Research Institute of Michigan is underway to collect moving ground clutter data for incorporation in the map simulation model using an airborne Synthetic Aperture Radar (SAR). A grant with Northeastern University is underway for developing an analytical Doppler radar clutter simulation program for airport environments. The results will be useful for corroborating the accuracy of the clutter modeling using SAR data. Also, under a contracted design study with the Sierra Nevada Corporation, we are evaluating the feasibility of a velocity gradient processing technique for detecting wind shear during takeoff, utilizing existing airborne weather radars. If this technique proves successful, modifications could be made to the existing radars, providing an interim technique for detecting wind shear hazard at takeoff.

Over the past 8 months, NASA has held detailed technical discussions with industry regarding the potential for airborne light detection and ranging (LIDAR) wind shear detection. These discussions focused on current technology readiness and likely future developments for both gas and solid-state lasers and related electro-optical techniques. An industry consortium, headed by Lockheed Missiles & Space, Inc., has been selected to conduct a LIDAR research program under NASA sponsorship. The initial phase of research focuses on performance/technology assessment for laser- based wind shear detection and avoidance and emphasizes comparison of solid-state and gas system options. NASA will provide the convective wind shear reference hazard environment and data base. The study parallels the technical approach of our radar program, allowing direct performance comparison of the two sensor technologies.

A number of major efforts remain to be completed that will help define the technology required for the development of an airborne wind shear detection system. We plan to complete a refined simulation program in FY 1989 which models the microburst phenomena, the radar performance, and the background clutter. We will also develop and evaluate techniques for suppressing the effects of the airport clutter environment in FY 1989. After an initial set of SAR clutter data is incorporated in the preliminary version of the simulation program, time domain output signals and Doppler spectrums will be generated and analyzed. Initial samples of these time domain signals will be provided to industry in FY 1988. As the development of the simulation program progresses and clutter modeling and analysis are completed, various prototype Doppler radar designs will be analyzed. This will lead to suitability assessment of Doppler radar for detection of low level wind shear and the development of a set of requirements for various Doppler radar designs in late FY 1989. To verify and evaluate results obtained through simulation modeling and analysis, we will develop a research Doppler radar scatterometer instrument in order to conduct ground and flight data collection experiments. Assuming a positive assessment of the Doppler radar suitability, experimental flight tests will be initiated in late FY 1991.

The initial Doppler LIDAR study will be completed in FY 1988. This study will provide a comprehensive assessment regarding suitability of airborne laser-based wind shear detection, prediction, and avoidance. LIDAR requirements and concept formulation will be determined using data bases derived from the NASA wind shear model which includes cloud microphysical processes that have large impact on sensor performance. Calculation of end-to-end system performance will be made to determine capabilities and limitations of candidate LIDAR concepts. Factors involved in the performance analysis include laser backscatter, atmospheric absorption, the effects of downdrafts, crosswinds, precipitation, turbulence, LIDAR pulse repetition frequency, the aircraft environment, system electrical efficiency and eye safety considerations. Based on results of the quantitative performance analysis, recommendations will be made for the most promising system concepts. A technology road map will be provided for the selected candidate concept and overall findings of the study will be transferred to industry through NASA sponsored workshops. The required future research efforts will be determined based on the study findings, concurrent in-house planning exercises, and industry recommendations.

In summary, working closely with the FAA, NASA has initiated a comprehensive research program to provide the necessary technology base for the airborne detection, warning, and avoidance of low-altitude wind shear. While NASA's aeronautics research and technology program places major emphasis on new vehicle technology and the fundamental disciplines that provide the base for new technology, an important aspect of the program is the investigation of phenomena critical to the safety of aircraft and the public. NASA has a number of unique facilities and researchers with special skills to bring to bear on safety-related issues. In accordance with NASA's charter, the safety-related research is conducted in support of, and in very close coordination with, the FAA which has the primary regulatory responsibility for aircraft safety.

Thank you, Mr. Chairman. That completes my prepared testimony. I would be happy to answer questions.

Mr. **Oberstar**. There is a vote on the House floor. Let us take this opportunity to invite our next witness, Mr. Mark Kirchner, of Boeing Airplane Company, to take the witness stand and swear him in, and recess for the vote and resume right afterwards.

Raise your right hand. Do you solemnly swear that the testimony you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. **Kirchner**. I do.

Mr. **Oberstar**. Thank you.

The subcommittee will stand in recess pending this vote.

[Recess.]

Mr. **Oberstar**. The subcommittee will resume its sitting. Because of the unanticipated interruption with votes, the Chair, in thinking it over, feels that it might be useful to move things along if we could have also our next witnesses, Mr. Gordon Bethune and Captain Jim Sifford of Piedmont Airlines, join Mr. Kirchner and testify in sequence.

We will have approximately an hour of respite before the next vote. But I would like to get the witnesses together.

Mr. Bethune and Captain Sifford?

Mr. **Murchison**. Mr. Chairman.

Mr. **Oberstar**. Yes?

Mr. **Murchison**. My name is David Murchison, from Piedmont Airlines. I am the Assistant General Counsel. Captain Sifford is here. Mr. Bethune has left the building for about half an hour to visit with Admiral Engen and he will be back within the next half-hour.

Mr. **Oberstar**. We will proceed.

Mr. **Murchison**. Perhaps Mr. Kirchner can begin and Mr. Bethune will be here any moment.

Mr. **Oberstar**. We will proceed as per the program then, given that the witness is not here.

Thank you, Mr. Kirchner. If you have testified before committees or observed the functioning of Congress, you know that this not an isolated phenomenon nor is it one that can be detected by any of the devices that we have discussed today, neither Terminal Doppler weather radar nor LLWAS nor any system of birdwatching can tell us when a vote is going to occur.

Mr. **Kirchner**. I understand.

Mr. **Oberstar**. Something in your bones tells you. [Laughter.]

TESTIMONY OF MARK KIRCHNER, DIRECTOR OF ENGINEERING TECHNOLOGY, BOEING COMMERCIAL AIRPLANE CO.

Mr. **Kirchner**. My name is Mark Kirchner. I am the Director of Engineering Technology for the Boeing Commercial Airplane Company.

I have submitted my written testimony for the record and at this time I would just simply like to emphasize a few of the more important points.

Mr. **Oberstar**. Your testimony will appear in full in the record.

Mr. **Kirchner**. I would like to give the committee, for its use, a copy of a videotape. This tape can be used as an executive overview of the wind shear training program. It is actually one of the video-tapes submitted as an end-item to the FAA contract. It has been designed for use by those who are involved in the wind shear program and, actually it can also be very interesting for those who are involved in the management of such programs, and for the committee itself. So I would like to leave this with the committee for perusal.

Mr. **Oberstar**. The committee will be happy to receive that information. We will include it and make it available for committee members for viewing. We greatly appreciate your making the tape available.

Mr. **Kirchner**. The FAA wind shear training program on which so many of us work is, and will continue to be, a success to a very large extent because of one important ingredient that was introduced into the strategy early in the program. That was the requirement for consensus among the various professional groups involved. I don't mean consensus in the sense of compromise. I mean consensus gained by working the problem in detail, in areas of uncertainty or disagreement, until sufficient insight has been gained to provide the required consensus.

How to handle wind shear involves so many complex questions, from flight techniques through training techniques, that any lack of consensus could provide a credibility gap and, therefore, a lack of acceptance of our recommendations. We could end up with nothing, without consensus.

I would like to report that a letter to FAA Administrator Engen fully endorsing the wind shear training program has been signed by representatives of the following organizations: the Boeing Company; Douglas Aircraft Company; Lockheed California; United Airlines; the Air Transport Association, ALPA—the Airline Pilots Association, as well as the Allied Pilots Association; NASA; the NTSB; and Aviation Weather Associates.

This letter not only endorses the program but consolidates certain other recommendations to the FAA concerning the wind shear issue.

This group, which provided critical reviews of the developing training program, was an expansion of the smaller contract group. Also, during the program, numerous other airlines and operators were invited to participate and comment on the program.

After formal release of the program earlier this year, industry, using its own funds, held seminars in London and Singapore to acquaint an additional sixty-four non-U.S. operators with the wind shear training program.

Today you have seen and heard about a few incidents relative to wind shear. I would like to tell you about another one that hasn't had any publicity. On June 11, earlier this month, a Delta Airlines 767 was landing at Atlanta. The crew had received wind shear training. The 767 had been equipped with wind shear alert and guidance units. The pilot, prior to approach, in consonance with his training, had requested wind shear advisories. No advisories were reported.

However, at three hundred feet altitude, the pilot, from his training, determined that he might be entering a hazardous wind shear condition. Continuing to follow procedures from his training, he elected to abort and go around, using wind shear flight penetration techniques in the process. Almost simultaneously with that decision, the aircraft wind shear alert sounded, and the aircraft wind shear go-around guidance was activated.

In other words, the pilot's training worked. The aircraft wind shear systems worked. The systems on the aircraft were designed to match what the pilot is trained to do, and it matched to a tee. Everything worked. The subsequent speed and path of the aircraft indicated that indeed a serious wind shear had been encountered. After a successful go-around and holding period, an uneventful landing was made. There was no incident to report.

I would like to report on the status of wind shear alert and guidance equipment, as installed in our aircraft. The Boeing system is now standard equipment on all new Boeing airplanes equipped with inertial reference systems. This includes the 767, the 757, the 737-300, and upcoming model 737-400 and the 747-400. Over one hundred of these systems have been delivered and are in operation.

The cost of these systems, which use the inertial reference system already in the aircraft, is about $150,000 for new production aircraft and about $35,000 to $40,000 for retrofit kits. The cost of retrofitting airplanes that are older than those which are mentioned above, depends heavily on the type of instrumentation already existing in the aircraft and the type of new system to be installed. So these costs could be quite high, much higher than those I have mentioned.

The alert feature, however, is much less expensive to retrofit than the guidance feature. Therefore, serious consideration should be given to requiring only the retrofit of the alert feature to older in-service aircraft.

Avionics equipment manufacturers such as Sperry, Sundstrand, Safeflite, Inflight Dynamics, are developing equipment for out-of-production airplanes. The results of the wind shear studies and technologies have been made available to these manufacturers. Also, we have provided the technical characteristics of the aircraft for which they are designing equipment. Industry is also supporting Airinc, the airline avionics standardization organization, in developing industry standards for non-inertial reference system-equipped aircraft. These are the older aircraft.

The wind shear training aid program and the wind shear equipment development program are just one part of the total FAA integrated wind shear program. We strongly support the rest of that program, which of course includes ground detection of wind shear and airborne detection systems.

Now, it is our understanding that the FAA improved or enhanced LLWAS system is scheduled to be installed by about 1989. We strongly support that system as a good interim measure. The FAA terminal Doppler radar system, designed to identify microbursts at the airport, which you have heard about today, will not have its first production terminal NEXRAD installation until about 1990. The follow-on systems designed specifically as Terminal Doppler weather radar systems will be first installed in 1993. We support continued funding of these important facilities, but you can see it's going to take a few years to even get them going.

Airborne detection systems are aimed at replacing our present terminal alert systems. Our present aircraft alert systems cannot look ahead, can the radar systems that have as has been described. They measure the conditions as you enter them and, therefore, alert you that you are in the process of encountering wind shear. The concept of airborne forward-looking detection is very attractive, but difficult technically. Now, the reason it's difficult technically is this. We have these very large radars that we are using for ground detection systems at airports. We are trying to do the same thing basically and put it on an airplane. So you can see how difficult it is to miniaturize that function and put it on an aircraft.

Because it is so difficult, different technologies have been tried in achieving these objectives. These examples are—and you have heard of some of them today: NASA is studying the Doppler radar system concept; Lockheed is working on advanced laser application, called LIDAR, and they are also working on that in conjunction with NASA; and turbulence prediction systems working on infrared sensor systems.

Now, these systems are in various stages of development. None is commercially available. I personally cannot predict when they might be, nor can I project their potential costs.

So, in summary, first I view the wind shear training aid to be the most effective near-term answer to the wind shear problem. We must train 25,000 flight crews out there. Many airlines are well into their programs, and it has already paid off handsomely.

Secondly, the implementation of the improved ground detection system is a must, since avoiding wind shear is the number one objective, and, at best, such a system will take a number of years to implement.

Finally, the effectiveness and cost of airborne detection systems must await specifications definition and prices and costs from those companies involved in the developments.

That is a summary of my remarks, Mr. Chairman. I would be happy to answer any questions.

Mr. OBERSTAR. Thank you very much, Mr. Kirchner, for that presentation and for the more detailed information you have provided in your written statement, which as I said will be included in the record in full because it does have a great deal of useful information.

Thank you also for sharing with us that other inspiring, even spine-tingling story about the pilot who did all the right things at the right time and saved his aircraft, his passengers most importantly, and lived to tell the story. It's wonderful when it all works together, and that's what we are working towards, that moment, that split-second point when the pilot's experience, judgment, and senses of all that is happening around him goes to work and it all works out.

Mr. KIRCHNER. And it all comes together. Right.

Mr. OBERSTAR. I have seen that happen in a simulator, and I think that we would like to hear more about how a simulator works. But before that, a thought occurred to me. Do you know whether the information was passed from that pilot to the tower and passed back to other aircraft following?

Mr. KIRCHNER. I am sure it was. He was a pilot who asked for wind shear advisories himself, which is part of our training process. If there are any of the indications that Dr. McCarthy talks about or showed on his slides and you will see in this videotape, the pilot is trained to inquire about wind shear advisories even if he isn't given any. In this case, there were none available; there were no advisories evident.

So a pilot who reacts correctly to a wind shear incident would certainly report his full process and experience to the tower.

Mr. **Oberstar**. You are in a unique position, representing Boeing Co. not only from a training standpoint, but one that is the leader or one of the leaders in aircraft technology in the entire world. Does Boeing have information as to whether aircraft are more vulnerable to wind shear at takeoff or a landing? Either one of those points that is the critical time?

Mr. **Kirchner**. I think the point of takeoff rotation is probably the most dangerous situation. Although I would say the 300-foot altitude at which this Delta Airline pilot was at would also be a very dangerous situation. In other words, he is near the ground, he is descending, and he has to arrest his descent at a time when his lifting capability is deteriorating rapidly. That is one of the worst sets of circumstances.

At takeoff you are in a similar situation if you are just at rotation, where you have rotated the airplane, and then a wind shear hits you and stays with you. That is very similar to what happened in the United case that was described a while back, at Denver. But they made it, and this captain made it too.

There are wind shears, which can hit you under those two circumstances that you can't survive, but for every one that you can't survive, there are probably thirty that you can survive. So those are the ones that we are going after.

Mr. **Oberstar**. Aren't there more options—or maybe plurality is not applicable. Isn't your option or your prospect better on landing than on takeoff? You at least have the option of flying through it. If you are at rotation, you don't have much choice.

Mr. **Kirchner**. Well, it's a similar case. As I said, you are in a descending mode on landing, and you must arrest that descent. You have this hundred tons of aircraft descending, and you must arrest that descent with a lift that is deteriorating due to the wind shear. On takeoff you need lift that you haven't created yet, and so it's a similar problem. You know, I would say they are both very important, and I would agree to the speculation that the occurrence is about fifty-fifty.

The way to best handle those situations is to avoid them. In both of those cases that you have described, where we are near the airport on landing and you are just about to rotate on takeoff, those situations would be most amenable to being detected by the ground detection systems that are being installed.

Mr. **Oberstar**. Thank you. That is very helpful. I think that is very important, understanding the effect on the aircraft in those two vulnerable positions and the options available to the pilot in order to know whether we are headed in the right direction with the technology and whether we're doing the right kinds of things to deal with the wind shear phenomena.

Mr. **Kirchner**. I might add that in our training program we deal with them both equally.

Mr. **Oberstar**. What is your assessment of the effectiveness of simulators and how are they used and at what point in pilot training should they be used? Should the simulator be done annually, annual review, or less frequent than annually?

Mr. **Kirchner**. The simulator is an absolute must. As was pointed out earlier, you can't just go out and find wind shears and practice flying in them. You wouldn't do it even if you could. So we do it with a simulator, and you need the simulator. You cannot gain the experience without the simulator.

With regard to frequency, the airlines have a training frequency that is required by the FAA. I think it's six months, but I am not an expert on that. Mr. Bethune would be able to testify on that. We would recommend that for his regular currency training, the wind shear be an integral part of it. It isn't that difficult to include.

Now, there are two kinds of wind shear training. One is flying the aircraft manually, where there are no wind shear alert and guidance units installed in the aircraft. So we are training the pilot to fly an aircraft that may be out there today that would encounter a wind shear. We will train him to do that in the simulator. In addition to that, as the equipment becomes installed on the aircraft, he will then get training with and without the wind shear equipment. And the equipment, as I mentioned before, is doing nothing more than helping him do what he was already trained manually to do. So it all builds on itself.

As we developed the training aids, many airlines who were involved in that process started integrating into their own training programs those aids for which consensus was gained during the actual development of the training aid program. So by the time we finished the training program, some of the airlines had their programs all in place, actually training pilots, like on 727 fleets.

Now, the equipment that has been placed on the aircraft is all relatively new. That equipment will be placed in the simulators as it becomes available for simulators, and then the training will be expanded to include training with the equipment onboard.

Mr. **Oberstar**. What is the cost of a simulator?

Mr. **Kirchner**. I can't testify to that. I think Piedmont may be able to help out there. They are very expensive. But that doesn't mean that an airline will not have a simulator available to it. If it doesn't have its own simulator, it can get simulator time from a larger operator that has one.

Mr. **Oberstar**. I know they run several hundreds of thousands of dollars.

Mr. **Kirchner**. Millions.

Mr. **Oberstar**. The more complex ones run to two to three million dollars.

Mr. **Kirchner**. Yes. In that order.

Mr. **Oberstar**. Does wind shear affect different aircraft in different ways? Does a 727 react in a given phenomenon differently than a 767 or 757?

Mr. **Kirchner**. I would say they react similarly. The reason that they do is that all aircraft have as a target approach speed a speed that is related to their minimum flying speed. So regardless of what the approach speed might be, the speed margin in terms of percent minimum flying speed is the same. So all aircraft are flying according to the FAA speed and margin regulations and, therefore, have a given speed margin available to them. When encountering wind shear, our training draws on the fact that what one should do is trade some of that speed margin for lift.

Now, the thing about that that is different from traditional training is that previously pilots were generally told to try to maintain that speed margin and not to trade the speed margin for lift. This was to stay away from the stall, which was considered the worst thing that could happen, so, "Never get near the stall." What we have found is that in the process of trying to maintain the speed margin the pilot might not arrest the descent of the aircraft in a wind shear and therefore impact the ground before he would have a chance to recover.

So we found that what one had to do is immediately start to arrest the descent of the aircraft using that speed margin, so-called splitting your margins between lift and speed, sharing them. And we found that all of the aircraft had very good low speed flying qualities and control. So the right thing to do was to split the margins rather than put them all on the speed side. This is the thing that is different from traditional training, and has been very valuable in the whole wind shear development.

Mr. OBERSTAR. So it doesn't really make a difference as to which aircraft the pilot is flying, but rather the trade-off between speed and lift.

Mr. KIRCHNER. That's right. Conceptually, that's right. Now, when you get down to the real numbers on how the aircraft is flown, it makes a difference between the airplanes. And we have studied all of the Douglas, the Lockheed, and the Boeing airplanes, and when instruments are developed for them and margins are determined for them, we take into account the actual aircraft because it does make a little bit of difference. But the general concept is the same.

Mr. OBERSTAR. Thank you. I will have further questions.

The gentleman from Pennsylvania?

Mr. CLINGER. Thank you.

Differing aircraft have a differential between landing speed and stall speed. On different aircraft it varies, does it not?

Mr. KIRCHNER. Well, our design objectives tend to be very similar. For example, at Boeing we have a rule of thumb that limits approach speed no higher than one hundred thirty-five knots. Now, generally speaking, the approach speed will be thirty percent higher than what we call the stall speed. The stall speed has a technical definition, and I won't get into that, but it is generally known as the minimum flying speed. Thirty percent speed margin.

If airplanes can, let's say, land adequately with a one hundred thirty-five knot approach speed, then they tend to grow in landing weight (due to payload growth) until they have that approximate approach speed. So they're not all that different. You might find a very light airplane with a large wing having an approach speed in the order of, let's say, one hundred ten knots, but even that isn't that much different from one hundred thirty-five, when you get right down to it, in terms of speed margins.

Basically, they are all up in the one hundred twenty-five to one hundred thirty with one hundred thirty-five being near the maximum. There is no rule of that; it's just sort of a good design parameter, based on experience.

Mr. CLINGER. Right. So that they are all roughly equal and similarly able to handle the wind shear situation.

Mr. KIRCHNER. Right.

Mr. CLINGER. In discussing your written statement, you mentioned that during wind shear encounters, unusual stick forces may be required and that these stick forces may have been perceived as unnatural. What does that mean? Could you elaborate on that?

Mr. KIRCHNER. Well, the way we design an airplane, we put what we call speed stability into it. That is, if you keep a light touch to the column, the control column, the airplane will tend to hold its speed. That means that if for some reason or other the airspeed decreases, the aircraft will tend to dip its nose and pick up speed. That is speed stability. Well, if you don't want the airplane to do that because you want to hold flight path and try to prevent a downward acceleration in a wind shear, you can see you're going to have to pull back more than you would otherwise. And because that is counter to the original idea of maintaining speed, then a pilot might encounter higher back-stick forces than he normally would use in his technique. And we now train that such conditions are acceptable.

If you recall earlier today someone said, "Well, a pilot is really only going to encounter one wind shear that is serious in a lifetime, if that many."

How do you train to cover something that you only encounter once in a lifetime? Well, the way you do it is to start introducing ideas which change how you fly the airplane normally. In case you do encounter a wind shear, that normal training will be the right thing for the wind shear as well. What's that? Let me tell you what it is.

Our traditional training was to maintain speed. Our new training is to maintain flight path. Well, if you encounter a wind shear and tend to sink, you won't maintain flight path.

So we're teaching pilots to maintain flight path. That is the right initial action upon encountering and penetrating wind shear. So let's say you're coming in to land at an airport and you're flying the instrument landing system. First, let's describe the type of wind shear. Let's say that first we have a headwind and then all of a sudden that reverses and becomes tailwind. That is typical in a wind shear.

The traditional system might be: maintain airspeed. So as you encounter the headwind, the pilot pulls back on power, otherwise he's going to increase his airspeed. But he has slowed down relative to the ground. And, then the headwind shifts to a tailwind, and suddenly the airspeed decreases. So he lets the nose dip, adds power, and tries to maintain airspeed. In the process, he has lost his energy with the first speed decrease, and then, in trying to maintain speed, he starts descending and he descends into the ground.

Now, the new system would be: maintain flight path track and let speed have some excursion. So now he enters the headwind, and he lets the airspeed build up, but he holds on flight path track. Now he gets a tailwind, the airspeed starts to bleed off, let it bleed off, hold the flight path track. Don't descend below the desired track.

Those are also the correct actions if it's a serious wind shear. So we start training like that in holding the flight path track and letting the speed have some excursion, and if he does that as a common way of flying the airplane, he automatically is doing the right thing when he gets into the wind shear.

So that is just an example, the kinds of training differences. We think they are working very well.

Mr. CLINGER. Is the ultimate instruction not to land if you're involved in an episode?

Mr. KIRCHNER. That's right. During landing approach, if you have an indication that you are in what we will call a serious wind shear, something that is not everyday, handlable, the instruction is to abort the landing and go around, using wind shear penetration flight techniques.

Mr. CLINGER. The Chairman was talking about simulators, and you indicated that it's absolutely essential for the pilots to be trained on the simulators. How readily available across the industry are they? In other words, is there a plentiful supply of these for training of commercial pilots?

Mr. KIRCHNER. Yes.

Mr. CLINGER. And do, in fact, all pilots have training in them?

Mr. KIRCHNER. Yes.

Mr. CLINGER. And you think it's sufficient training?

Mr. KIRCHNER. To my knowledge, of the airlines I deal with, you know, they all have simulators available. I can't actually testify that every single one does. You see, the FAA, in its certification of the airlines to F.A.R. Part 121, has to certify that the airline's training program is adequate and meets the regulations. Now, as long as the airline does that, they are certified to train according to that program and operate the airline. That is the requirement that they must satisfy; I am not sure what all the airlines have done in order to satisfy the FAA in that regard.

If the FAA requires wind shear training of all commercial transport pilots through the simulator, then each airline, in order to gain their Part 121 certification, would have to demonstrate to the FAA how they are doing that, one way or the other.

Mr. CLINGER. And this would apply to small commuter lines as well as to the large airlines?

Mr. KIRCHNER. Well, they have different certification requirements for different forms of service, from air taxi all the way up to commercial transport. So I am really talking about commercial transport.

Mr. CLINGER. Commercial transportation. In general, would smaller commuter-type aircraft be less or more able to handle a wind shear situation?

Mr. KIRCHNER. I would say that if they are of a class of the aircraft that are commercial aircraft like, let's say, some of the large commuter aircraft, turboprops, small jets, then they would be very similar to the commercial large aircraft. As you get down to the air taxi——

Mr. CLINGER. Like a Beechcraft 99?

Mr. KIRCHNER. Well, those are shading on the large side. But smaller than that, then I would say all of the alert, all of the avoid, all of the detection technology would be just as important to be the same. With regard to flying technique, it might be somewhat different.

Mr. CLINGER. Different? Harder or less difficult?

Mr. KIRCHNER. It's hard for me to say. It might be different. I really can't comment on that.

Mr. CLINGER. All right.

Mr. KIRCHNER. But I think the reason that we felt strongly about getting the FAA wind shear training program for commercial aircraft off and going by itself was so at least we had a point of departure so that others, including the FAA and these other types of aircraft, could study what we'd learned and go from there to see how it might apply to these other aircraft.

Mr. CLINGER. All right. Thank you.

Thank you, Mr. Chairman.

Mr. OBERSTAR. Thank you.

Are onboard air detection systems difficult to develop?

Mr. KIRCHNER. Yes.

Mr. OBERSTAR. They are more complex than the ground-based systems? I think we had some testimony to that effect.

Mr. KIRCHNER. Well, the reason they're difficult is because they are trying to accomplish the same function as a ground system with a very small unit that will fit in an airplane rather than a very large unit that will fit into a building.

Mr. OBERSTAR. Right. Then what are the complexities of uplinking ground-based information to an aircraft moving into a weather system?

Mr. KIRCHNER. Well, my views on that are as follows: I really think the difficulty is in somehow determining when we are going to call a phenomenon a wind shear, how to say where it is. Once you do that, I believe the uplink can be done very easily with the tower controller because it doesn't take that long to convey the information. The problem is figuring out what he should say, and where he gets the information from to say it.

If I were on a final approach, the tower operator would normally have plenty of time to advise me of any developing situation, very briefly, if we could figure out what he says and from where he gets the information. So I believe the uplink is very easy.

Mr. OBERSTAR. You would feel comfortable relying on the tower controller to relay that information?

Mr. KIRCHNER. Yes, because you don't have to be a meteorologist to relay that information. You have to be a meteorologist to determine the factors in the first place and pass the information along to the tower; and then the tower is the communicator.

We have to have standard phraseology, standard understandings of what the warning options are so that there is no misunderstanding about what the tower means. The message must be perfectly clear where it is, what it is, and what the pilot can expect.

Mr. OBERSTAR. Is there a threshold of wind shear or microburst force below which such phenomena are not serious?

Mr. KIRCHNER. Yes. There is a complete continuum of wind shear from zero all the way to very, very high values. It's just a continuous thing. The higher the value of wind shear, the less likely it is to occur. But one might say that there is a level which is so low, like, let's say ten knots to fifteen knots, which is still a wind shear that is perfectly within the average pilot's experience and he would have no trouble handling. You start getting above fifteen knots, and now you are getting into what we would call the wind shear phenomena. But it's really just an extension of the same.

Mr. OBERSTAR. What is the level for the Boeing detection system?

Mr. KIRCHNER. Well, it's more complicated than just detecting a windspeed change, per se. But it's on the order of magnitude of the equivalent of fifteen knots, I believe.

Mr. OBERSTAR. I had understood from other information the committee received in preparation for the hearing that windthrust in a wind shear or microburst situation of as little as ten knots can affect the aircraft performance, can be adverse.

Mr. KIRCHNER. Oh, yes, it can be adverse. But I would say it would be well within most pilots'—that phenomenon is common enough so that it would be well within a pilot's experience in flying gusty weather.

Mr. OBERSTAR. Can you put some other parameter on it? Above ten knots, above twenty knots, above thirty knots?

Mr. KIRCHNER. Well, it perhaps——

Mr. OBERSTAR. Or would you rather not characterize it?

Mr. KIRCHNER. I think it would be difficult to characterize it completely because it's a little bit more complicated than that.

Mr. OBERSTAR. All right.

Mr. KIRCHNER. But it's like that. It's like that.

Mr. OBERSTAR. All right.

Mr. KIRCHNER. It's like fifteen knots order of magnitude. You know, back in the wind shear committee meetings we had discussion on what the various members thought a serious wind shear in magnitude was, and at that time opinions were just laid on the table ranging from fifteen knots, twenty knots, to twenty-five knots. And I am not sure exactly at what point our alert system triggers.

What you do when you develop the system is this. You would like the system to trigger at the lowest level that would not create a nuisance, so that you aren't rejecting your landings quite often just because you're getting an early trigger. Yet, we'd like the trigger to, in fact, warn you when there really is a serious wind shear.

Mr. OBERSTAR. That is what I was getting at.

Mr. KIRCHNER. So what you do is to put these detection devices on an aircraft and you fly hundreds, thousands of landings with them and get data. And then, looking at that data, you say, "What warning threshold would hardly ever give me an alert? I wouldn't mind having a lot more alerts than I have wind shears, but I just don't want them to be very often." And by looking at such data and making judgments, you set your alert threshold.

Mr. OBERSTAR. So you are looking for something that doesn't give you false positives?

Mr. KIRCHNER. Right.

Mr. Oberstar. But which does give you solid information on which to make responsible judgments.

Mr. Kirchner. Right. You certainly don't mind aborting a landing occasionally when there really wasn't a wind shear there, as long as it isn't real often.

Mr. Oberstar. Yes.

Mr. Kirchner. But on the other hand, you would like it to catch every serious wind shear, every one of them.

Mr. Oberstar. What are the early warning signs that pilots and controllers must be alerted to in order to be on guard about a dangerous weather system?

Mr. Kirchner. Well, in the training——

Mr. Oberstar. And how do you train for those, yes.

Mr. Kirchner. The pilots and the controllers, everyone involved, are shown the kinds of things that Dr. McCarthy showed on the screen in more detail, to show the kinds of situations where wind shear could occur. Then, once there is an awareness of the meteorological conditions where wind shear can exist, now it's a matter of paying attention to what you're doing and trying to recognize any early warning. This is without equipment; this is without ground detection equipment, this is without aircraft equipment. Then you superimpose the ground detection systems that are being developed by the FAA or you superimpose the aircraft-borne systems, and all that builds to a higher and higher level of probability of early identification of a wind shear and the proper action to be taken.

Our pilots at Boeing—these are our test pilots and the people who participate in the development of wind shear detection—feel that without any equipment on the ground or in the airplane, if we train the people properly according to the wind shear training techniques that we have all developed, that we may get eighty percent of the way to our goal. Then you put in the equipment in the aircraft and then you can get ninety to ninety-five percent of the goal. And maybe the last five percent will elude us.

The ground detection system. If you can avoid the wind shear altogether, and you just don't fly there, and it's a good system so it detects, in fact, the wind shear, then that in itself would be a separate check. Maybe one hundred percent there. Anyway, when we bring these parallel things along, I am very optimistic that we are going to get very close to our ultimate goal of no accidents.

Mr. Oberstar. Well, I certainly hope so, and we are going to provide whatever technology or funding for technology may be necessary to help you achieve that goal, and I know you are going to continue working toward that objective.

We understand, though, that the recommended wind shear escape maneuvers in the Boeing training program are not universally accepted by pilots. Do you have any idea of what might be their objections?

Mr. Kirchner. Well, I feel that the consensus that we have gives us a representation of all piloting groups. So the responsible people within those piloting groups—including the Air Line Pilots Association, airlines, industry—there is a consensus that our techniques are the right ones. So I feel that any exception from that is something that we can't avoid, probably, but I don't think it's a concern.

Mr. OBERSTAR. If airlines do not own their own simulator equipment, are there enough companies available to provide that training as a service for fee?

Mr. KIRCHNER. Yes.

Mr. OBERSTAR. Does Boeing offer this, or are there other airlines and nonairline companies that do so, like, say, Simuflight Company in Dallas?

Mr. KIRCHNER. My understanding is that there are sufficient companies that offer this service. Our simulators—we have training simulators—we generally have them fully occupied introducing new airlines into our training process. So we don't normally offer regular training; that is, the repetitive, recurrent training. But there are services available.

Mr. OBERSTAR. Are there any airlines to your knowledge that do not have a wind shear training program?

Mr. KIRCHNER. I am sure that there are, but not to my knowledge.

Mr. OBERSTAR. Should they all have one?

Mr. KIRCHNER. Yes, they should.

Mr. OBERSTAR. That is certainly not beyond cost to provide that training.

Mr. KIRCHNER. I don't believe it is.

Mr. OBERSTAR. Is this wind shear training program that Boeing has developed and others have developed available for general aviation and within reasonable cost?

Mr. KIRCHNER. I think it could be made available to general aviation very easily. I think the most effective parts of the wind shear training aid program would be the recognition of the weather phenomena, how to avoid wind shear—that is the most important part anyway. The kind of tape that I have left here could be shown by the FAA at safety seminars around the country. The FAA conducts these regularly in various parts of the country. These kinds of things could be shown and I think give a very high degree of awareness to the general aviation community of the wind shear problem.

They could also get a general idea of what we are training for the commercial transport in the way of recovery techniques. I don't know that it would apply that much to very light aircraft. I think the general understanding that would be gained would be very helpful.

Mr. OBERSTAR. You heard the testimony earlier today from the witnesses about the status of progress in research and development of wind shear and microburst detection technology of the various sorts, both ground-based and airborne. Do you feel that development of these programs and their movement into use is on target or ahead of target or too slow?

Mr. KIRCHNER. I think that it's about right. I think the funding of the production detection system would be the most difficult.

Mr. OBERSTAR. Why?

Mr. KIRCHNER. Well, because it involves the most dollars. In other words, I think there are enough dollars out there to do the kind of research required for the ground detection system.

Now, the airborne detection system work, as I said before, is more difficult technically, and I think that research and development support of such activities is important. I can't comment as to whether I think the level is adequate because I don't really don't know what the level is.

But when you look at the total FAA integrated wind shear program, it seems to me that the dollars are the biggest for the implementation of the ground detection systems, and I would like to support that funding.

Mr. **Oberstar**. Well, from this side of the aisle, we certainly will be providing funding as needed, as necessary, and in the amounts required to provide the maximum safety. The question is do we have the right technology and are we moving ahead as fast as we should or should we move ahead faster?

Mr. **Kirchner**. Well, I really think the ground detection is in hand, essentially. Dr. McCarthy talks about the algorithms required to take all the data that comes from the radar and then recognize the wind shear from that data. Now, that is a very important technical job. I believe that he and others will do a good job in this area. I can't speak to the required level of funding. I don't know what it is. As I say, in airborne systems, I can't speak to the funding level required either.

I do support the developments. I think they are working in the only areas that are fruitful. So whatever funding level is required, I would like to see them get it.

Mr. **Oberstar**. Thank you very, very much, Mr. Kirchner. We greatly appreciate your presentation today.

Mr. **Kirchner**. Thank you.

[The prepared statement of Mr. Kirchner follows:]

STATEMENT OF
MARK E. KIRCHNER
DIRECTOR OF ENGINEERING TECHNOLOGY
THE BOEING COMMERCIAL AIRPLANE COMPANY

BEFORE THE

SUBCOMMITTEE ON OVERSIGHT AND INVESTIGATIONS

COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION

U. S. HOUSE OF REPRESENTATIVES

REGARDING

WINDSHEAR

JUNE 30, 1987

M. E. KIRCHNER TESTIMONY
BEFORE REP. OBERSTAR
JUNE 30, 1987

My name is Mark Kirchner. I am the Director of Engineering Technology for the Boeing Commercial Airplane Company. I appreciate the opportunity to testify before this committee. Our industry continues to play a key leadership role in developing ways and means of reducing the hazards associated with windshear.

WINDSHEAR TRAINING AND COCKPIT AIDS
A COMPREHENSIVE INDUSTRY APPROACH

INTRODUCTION

Windshear has been identified as a contributing factor in at least thirty-two transport aircraft accidents or incidents during the past twenty-two years. The accidents have resulted in over 600 fatalities and almost 250 injuries. Numerous "close-calls" that have not resulted in damage or loss of life have also been attributed to windshear. In the last ten years, in the continental United States, almost half of all transport aircraft fatalities during takeoff and landing have resulted from accidents in which windshear was found to be a major contributing factor.

Industry has recently made substantial progress towards reducing the windshear hazard. A Boeing led, FAA sponsored, industry team has just completed the development of a comprehensive windshear training program. The training program is designed to improve the capability of pilots to recognize and AVOID windshear, or failing to do so, to use effective windshear recovery techniques. At the same time, and as a supplement to the training, windshear cockpit systems have been developed and placed in service that alert the crew to the presence of windshear and provide pitch guidance information to assist in the recovery. These two developments represent the most effective near-term steps in combatting the windshear threat.

The ultimate solution will occur when severe windshear can be detected reliably and its location made known to the flight crew in time for them to AVOID it. The FAA, in cooperation with industry and the research community has developed an Integrated Windshear Plan designed to achieve this goal. The plan calls for development of both ground based and airborne windshear detection and alerting systems that should dramatically improve the capability for crews to AVOID severe windshear. Such systems however will not be operational for a number of years. In the near term, crews must rely not only on their judgement to AVOID windshear, but must also utilize the recently-developed improvements in training and on-board systems.

An emphasis on avoidance, and the development and implementation of effective windshear training and cockpit aids, represents a comprehensive industry effort to tackle the windshear hazard.

FAA - BOEING WINDSHEAR TRAINING AID PROGRAM

INTRODUCTION

Congressional concern following a 1982 windshear accident in New Orleans resulted in a National Academy of Sciences commissioned study by the National Research Council (NRC), which assessed the hazards of low-altitude windshear on takeoff and landing flight operations. One of the primary recommendations of the study group was to establish an integrated windshear program. The group specifically recommended in its final report, *Low-Altitude Windshear and Its Hazard to Aviation*, that *the FAA and the industry should prepare and disseminate, as widely as possible, updated and authoritative information on windshear* to better educate pilots and controllers. In response to the NRC recommendation and the needs of industry, Boeing entered into discussions with the FAA resulting in a Boeing proposal for a program to develop a Windshear Training Aid. In November 1985, the FAA contracted with the Boeing Company as prime contractor and McDonnell Douglas, Lockheed, United Airlines, Aviation Weather Associated and Helliwell Inc.......... as subcontractors, to produce the "Windshear Training Aid". The fifteen month program was completed in February 1987 with delivery to the FAA of four documents and two video tapes which provide the basic resources for a comprehensive windshear training program.

The Training Aid presents an effective means of training flight crews to minimize the windshear threat through avoidance and cockpit recognition and recovery techniques. It is applicable to all current Boeing commercial jet transport models as well as those manufactured by McDonnell Douglas and Lockheed. An industry-wide consensus was developed on all major training, piloting and technical issues through a review process that included representatives from the airlines, the pilot community, research organizations as well as government regulatory and safety agencies.

The Windshear Training Aid is comprised of the following documents and videos:

1) WINDSHEAR OVERVIEW FOR MANAGEMENT (program overview)

2) PILOT WINDSHEAR GUIDE (summary of key windshear piloting, training, and technical issues)

3) EXAMPLE WINDSHEAR TRAINING PROGRAM (description of ground and simulator windshear training program)

4) WINDSHEAR SUBSTANTIATING DATA (technical substantiation for all training and piloting recommendations)

5) A WINDSHEAR AVOIDED (video on key meteorological and recognition/avoidance aspects of windshear)

6) WINDSHEAR - WHAT THE CREW CAN DO (video on cockpit recognition and recovery technique for inadvertant windshear encounters).

In April 1987 the FAA distributed the Windshear Training Aid Documents and Videos to all Part 121 and 135 operators as well as other organizations within the air transport community, both domestic and overseas. In addition, the Boeing Company, McDonnell Douglas and Lockheed conducted joint manufacturers windshear seminars to brief their overseas customers on the Windshear Training Aid program. These one-day seminars took place in London (28 May 87) and Singapore (2 June 87). The Windshear documents were distributed to all participants at that time, and arrangements were made to provide the videos upon request. The manufacturers also plan to distribute the documents and videos to those overseas operators who were unable to attend the two seminars.

INDUSTRY CONSENSUS

General industry agreement on the Training Aid content was considered essential in order to assure the widest possible adaptation of the recommended training program. The Windshear Training Aid was developed by a consortium of aviation experts, and an extensive industry review process was conducted during all phases of its development. In this manner, an industry-wide consensus on all technical, piloting and training issues was achieved.

The parties responsible for development of the Windshear Training Aid included the FAA as contract manager, the Boeing Company as prime contractor with Douglas and Lockheed participating in the development of technical conclusions assuring applicability over the broadest range of U.S. manufactured jet transports. United Airlines' primary responsibility was the development of the Example Windshear Training Program. Aviation Weather Associates provided unique expertise in windshear meteorology, and Helliwell, Inc. produced the video presentations. The majority of team members were either pilots or people with flight operations responsibilities. Their contributions were considered essential since they represent the end user of the training program.

Two teams were set up to review the material as it was being developed. The prime review team was made up of organizations representing the airlines, the manufacturers, the pilots, the research community, and government regulatory and safety agencies. Specifically included were the Air Transport Association (ATA), the International Air Transport Association (IATA), the Aerospace Industries Association (AIA), the Air Line Pilots Association (ALPA), the Allied Pilots Association (APA), the National Aeronautics and Space Administration (NASA), the National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA). The second review team included domestic and overseas aircraft manufacturers who were not part of the contract team, windshear systems suppliers, simulator manufacturers, training organizations including those from the armed services, and representatives from the regional airlines, general aviation groups, the International Civil Aviation Organization (ICAO), and overseas aviation regulatory agencies.

The consensus development review process required numerous meetings first among contract team members to develop the draft documents and videos and then individually with the two review teams. This review, feedback and update process was repeated several times until an overall consensus was achieved. In all, over fifty meetings were convened among the contract team members and the two review teams. The final documents and videos were delivered to the FAA under a cover letter to the FAA Administrator D. D. Engen, signed by all representatives of the contract team and the prime review team, indicating their endorsement of the Windshear Training Aid.

TRAINING PROGRAM

Training Objectives

The objectives of the training program are:

1) Improve the capability of crews to recognize and thus avoid windshear, or failing to do this,

2) Recognize cockpit indications of windshear and initiate effective recovery action.

The training program is designed to increase crew awareness of fundamental lessons that have been learned from studies of windshear related accidents and incidents. The key lessons learned can be summarized as follows:

- Windshear avoidance is the best defense. Windshear exceeding the performance capability of any commercial jet transport and the most highly skilled pilot has been measured.
- The windshear events recorded by aircraft have been very similar in size; they are typically one to two miles in diameter and have occurred near the ground (below 500 ft.) during takeoff and landing operations.
- There is limited time for windshear recognition and action, typically only 5 to 15 seconds.
- Windshear recognition is difficult. Several factors can impede windshear recognition.
  - a) Past training that emphasizes airspeed control
  - b) Marginal weather conditions
  - c) High crew work load conditions
  - d) Illusion of normality: during the initial part of the windshear encounter, everything may appear normal; even severe windshear onset may not provide dramatic early indictions to the flight crew.
- Flight path must be controlled through pitch attitude. A downward change in pitch attitude can be perceived as a normal response to low airspeed.
- Unusual stick forces may be required to maintain pitch attitude during airspeed variations away from normal target airspeed. In accidents and incidents these stick forces may have been perceived as unnatural.
- Low airspeed must be accepted. Flying at airspeeds below normal reference speeds may be required in order to utilize the full performance capability of the airplane.
- Flight crew must coordinate. The crew's ability to recognize an inadvertent windshear encounter and respond correctly required coordination of crew responsibilities.

- In accidents and incidents, there was a lack of communication between the flight crews and the controllers: pilots either know of a problem, but didn't report it or the reports made were not specific, did not meet the requirements of the PIREP, or weren't disseminated.
- In accidents and incidents, there was evidence of severe weather in the area, such as convective activity, thunderstorms, heavy rain, and blowing dust, all conducive to windshear.

The training program is designed to address these lessons to help ensure that a flight crew will avoid windshear if possible, and respond promptly and effectively if a windshear is inadvertently encountered.

Model of Flight Crew Actions

In order to teach the principles of recognition, avoidance and recovery, an orderly set of actions, known as the "Model of Flight Crew Actions" is provided. This action model is essentially a check list and is designed to reinforce good airmanship. If used on a daily basis it will enhance the crews ability to recognize windshear and thus avoid it. The techniques advocated will also allow earlier recognition of an inadvertent windshear encounter so that effective recovery actions can be initiated without delay.

The first step is to EVALUATE THE WEATHER and look for any signs of windshear. A decision on whether to continue or AVOID is made based on guidelines that have been provided in the documentation. If it is judged safe to continue, but some weak indicators of windshear are present, certain PRECAUTIONS can be taken in order to reduce the risk if a windshear should inadvertently be encountered. These include use of the longest suitable runway, use of full takeoff thrust (rather than a derated level), use of increased rotation/approach speed and use of recommended takeoff/approach flap settings. STANDARD OPERATING TECHNIQUES which stress crew awareness of normal airplane parameters, use of pitch attitude control during takeoff and landing, and effective crew coordination, should be practiced on a daily basis. These techniques will enhance recognition if a windshear is encountered. If this should occur, the crew has to take the final step; the WINDSHEAR RECOVERY. The techniques requires aggressively applying thrust, pitching towards an initial target attitude of 15 degrees and maintaining the existing airplane configuration. The objective of the technique is to keep the airplane flying as long as possible in the hope of exiting the shear.

Training Program Content

Teaching the use of the "Model of Flight Crew Actions" forms the basis for the training program. The training program consists of both ground training and simulator training. The ground training program can be used to teach all elements of the crew actions model but emphasis is placed on weather evaluation practice and in gaining familiarity with the avoidance criteria. The emphasis in the simulator training program is to teach windshear recognition from the cockpit indictors and to practice the recovery technique itself.

The primary knowledge resources available for ground training are provided by the documents and videos. Skill in windshear recognition and avoidance is developed by use of Weather Evaluation Exercises. The ground training program provides 12 operational weather evaluation exercises designed to increase a pilot's understanding of weather information, ordinarily at his disposal, from which he may be able to determine the possible presence of microburst windshear which can threaten flight operations during takeoff or landing. Each weather evaluation exercise is designed to present a situation (e.g. in dispatch, taxiing for takeoff, commencing approach) and weather information from which the pilot must rate the probability of microburst windshear presence. To aid the pilot in making this determination, each exercise provides a set of specific weather questions, called evaluation factors. Based on these evaluation factors, the probability of a microburst windshear can then be assessed using guidelines which have been developed. The pilot then is asked to decide on a course of action based on his assessment of the weather.

The documents and videos also provide the knowledge resources for teaching cockpit recognition of windshear and the recovery technique. Annotated simulator exercises are provided as a teaching tool for situations where an actual simulator is not available. These exercises are a series of piloted simulator time-history plots that can be used to illustrate graphically the airplane/pilot response to a series of different windshear encounters during takeoff and landing. Both correct and incorrect recovery techniques are illustrated. However, development of skill in cockpit recognition and recovery can most effectively be done on the simulator. This device exposes the pilot to windshear encounters that illustrate the difficulties of recognition and allows practice of the recovery technique in a real-time, dynamic environment. The three basic types of windshear encounters simulated include an encounter on the runway prior to V_R, at or after liftoff, and during the approach. These three basic exercises use relatively simple linear wind models simulating increasing tailwind shears and, in one option, a downdraft. They are designed to teach the basic principles of cockpit recognition and recovery in an effective and repeatable manner. More complex wind models incorporating headwinds, tailwinds, updrafts, downdrafts and crosswinds are also provided. These models can be used to illustrate the additional complexities possible in a windshear encounter and to demonstrate the effectiveness of the basic recovery technique in a more turbulent and complex wind environment.

The windshear magnitudes recommended for simulator training are designed to result in successful recoveries if timely recognition has occurred and the recommended recovery technique is properly applied. If an operator wishes to demonstrate non-survivable windshear encounters, guidelines for development of appropriate wind models are also provided.

Training Program Implementation

The following actions will generally be required to set up a training program:

1) Training of experts whose task will be to develop the training program to suite the needs of individual operators and to verify it.

2) Implementation of windshear models in flight simulators if such simulators are available.

3) Restructuring of programs to fit the training into initial and recurrent training as desired.

4) Training of instructors.

It is recognized that item 2, the wind model implementation, may pose a particular problem for many carriers. The importance of using simulators, where available, cannot be over-emphasized. Consideration should be given to employing whatever means necessary to implement the recommended wind models. Typically, new simulators with user-friendly languages such as FORTRAN will require about one man-month of software development including about 20 hours of simulator time to debug and "tune" the models as described in the Example Training Program. For older simulators, these requirements may be greater.

Allocation of windshear training time within recurrent and transition training programs will vary from airline to airline. A typical program may be expected to consume approximately 30 minutes during a simulator session, backed up by at lest one hour of classroom training. The video presentations may replace, or be used in addition to, the classroom time.

Instructors should be given adequate time to assimilate the Pilot Windshear Guide completely, gain further insight by studying the Windshear Substantiating Data document, familiarize themselves with the simulator exercises selected, and develop a classroom briefing if appropriate. A slide presentation is provided that could form the basis for this briefing.

DOCUMENT SUMMARY

Four documents and two videos have been developed which provide the educational material and example training program that can be used by airline training departments to produce airline specific training programs.

Windshear Substantiating Data

The Windshear Substantiating Data forms the basis for all the documents and provides the technical substantiation for all recommendations made. The windshear weather section presents the state of windshear knowledge as of the publication date. Lessons learned from the study of windshear related accidents and incidents are described in detail. Flight crew actions and the reasons for them are outlined to aid in preventing future accidents.

Windshear Overview for Management

This document is aimed at airline management and training departments. It provides an overview of the entire training program, indicating why this training is important and what its primary objectives are. It also provides an assessment of the resources required to implement the program.

Pilot Windshear Guide

The Pilot Windshear Guide is a synopsis of the Windshear Substantiating Data and is organized in a like manner to facilitate cross-referencing. The guide is a highly readable, concise treatment of pilot issues, written by pilots, for pilots. It is intended for home study use. Pilots should be encouraged to become familiar with the material in the guide prior to ground and simulator training.

Example Windshear Training Program

The Example Windshear Training Program is a stand-alone resource designed to serve the needs of a training department. Included are both a ground training program and a simulator training program. Ground training lends itself to windshear education and avoidance strategies, while cockpit recognition and recovery techniques are best practiced in the simulator training. Use of the videos in the ground training is suggested. One section of the training program addresses the implementation of wind models in flight simulators and is offered as guidance for the simulation technical staff. A Pilot Windshear Briefing in the form of a slide presentation, with accompanying text, is also provided. The presentation addresses all key aspects of windshear and may be used to reinforce the Pilot Windshear Guide material.

Video 1, "A Windshear Avoided"

This video provides general windshear educational material, with emphasis on the meteorological aspects of windshear, including recognition and avoidance guidelines. Key lessons learned from analysis of windshear related accidents and incidents are also described. This video is designed not only for pilot briefings, but may be used to heighten windshear awareness for all personnel engaged in the air transport system, particularly, air traffic controllers and airline operations departments.

Video 2, "Windshear - What the Crew Can Do"

This video outlines effective recovery techniques when avoidance has failed and a windshear has been encountered. In addition, standard operating techniques which may aid in windshear recognition and precautionary steps in case of suspected windshear are also discussed. This video is designed for use as part of the pre-simulator pilot briefing, supplementing the Pilot Windshear Guide review material.

SUMMARY

The recently completed Windshear Training Aid documents and videos present the latest air transport industry findings on windshear education and training. The technical data and training recommendations were developed through an extensive review process, and represent a wide industry consensus. The training aid is intended to assist any airline in the creation or update of their own windshear training program. The need for effective windshear training is well established. Operators are encouraged to distribute these documents and videos to the appropriate personnel, formulate a windshear training policy with emphasis on avoidance and recovery technique training, and, with minimum delay, design and implement a windshear training program suited to their needs.

COCKPIT SYSTEMS ENHANCEMENTS FOR WINDSHEAR

INTRODUCTION

Recently Boeing, as well as other manufacturers, have developed and implemented onboard airplane systems enhancements for use in windshear encounters. These cockpit aids alert the crew when a windshear is encountered and provide guidance information on how to most effectively counter the windshear. Future onboard alerting systems are expected to have look-ahead capability. These systems will be able to detect and warn a crew of the presence of windshear well before it is actually encountered, thus significantly improving the capability to avoid windshear.

CURRENT TECHNOLOGY - BOEING

Current Boeing cockpit windshear systems are designed for operational compatibility with the manual windshear procedures advocated in the FAA sponsored Windshear Training Aid. As with the training program, the system design was influenced to a large extend by the lessons learned from analysis of windshear-related accidents and incidents. It was learned that in a typical windshear encounter on approach or takeoff:

- There is limited time for flight crew recognition of windshear and the initiation of recovery action.
- Early recognition by the flight crew of a windshear encounter is difficult.
- Proper thrust management is important.
- Appropriate control of airplane pitch attitude is required.
- Low airspeed must be accepted while at the same time stick shaker must be respected to ensure stall margins.
- Crew coordination aids the recovery process.

These findings suggest design objectives for windshear systems enhancements to aid the flight crew in coping with an inadvertent windshear encounter: (1) the system enhancements should shorten the time it takes the flight crew to recognize windshear. (2), guidance should be provided to make use of airplane capability at low airspeeds, while maintaining stall margins. (3), the enhancements should not interfere with crew coordination or be distracting.

Flight simulators were utilized to further define the concept. During the study many pilots from Boeing, the FAA, and several airline operators flew in simulated windshear scenarios and provided their comments and insight. The piloting group stated that:

- The system must be nuisance free.

  Above all, any alerting system must be as free from nuisances as practically possible. Pilot confidence would be quickly eroded if the alterting system gave warnings when no danger existed.

- **The guidance must be simple to interpret.**

  Severe windshear encounters are infrequent and a device that is complicated and/or infrequently used would reduce the probability of correct use when windshear is encountered.

- The guidance information should be presented on the Attitude Director Indicator (ADI)

  Pilots indicated that in the high stress and time critical environment of a windshear encounter, instrument scan tends to be reduced and focused on only a few instruments. The introduction of any new instruments into the scan or even adequate scan of existing instruments is difficult. The guidance should focus on attitude since the *problem* is the appropriate control of pitch and roll.

- The guidance should be universally applicable

  The same guidance should be applicable to takeoff, landing, VFR, IFR, precision and non-precision approaches. Since the presence of windshear or its location cannot be pre-determined, the same procedures must apply to all situations.

These design objectives and philosophies led to development of three systems for new generation Boeing airplanes; a windshear alert, enhanced flight director guidance, and a new display on the Electronic Attitude Director Indicator (EADI) called the Pitch Limit Indicator (PLI). Currently, over one hundred windshear systems have been delivered and are in regular scheduled airline service aboard 737-300 and 767 airplanes. The following describes these systems in more detail.

Windshear Alert

Piloted simulator studies of windshear encounters indicate that timely recognition of a windshear is difficult especially under marginal weather conditions at a low altitude.

The Inertial Reference System (IRS) on many of today's later technology airplanes provides data which can assist in the real time detection of windshear. The difficult part of the alert design however, is to determine threshold values of windshear that pose a threat to the airplane versus those that do not and are merely a nuisance.

The windshear alert warns the crew of windshear conditions that approach the limiting performance capabilities of the airplane. It does not annunciate shears of the type which require only routine piloting effort. As a result, the alterting signal is considered a warning level and specific crew actions are expected. When the alert occurs the pilot is expected to apply maximum thrust and execute a windshear recovery procedure.

The windshear warning logic resides in the Ground Proximity Warning Computer (GPWC). The system uses inertial and air data inputs to calculate and monitor wind energy relative to the airplane. When the wind energy exceeds a pre-determined threshold, aural and visual alerts are provided on the flight deck. The aural alert consists of a two tone attention-getting sound immediately followed by a voice annunciation of **WINDSHEAR, WINDSHEAR, WINDSHEAR.** This aural alert has priority [illegible] form of red annunciator lights imprinted with the word **WINDSHEAR**. The 737 uses one **WINDSHEAR** annunciator light and a windshear warning message on each EADI. On the 757 and 767, the master warning light in front of each crew member, a **WINDSHEAR** annunciator light on the center panel and a windshear warning message on each EADI will illuminate. Visual indications remain illuminated until the windshear condition dissipates. The alert is enabled at rotation during takeoff and remains enabled up to 1500 feet radio altitude. On approach the alert is enabled at 1500 feet radio altitude and remains enabled until touchdown.

An in-service evaluation of the windshear alert algorithm to verify the absence of nuisance warnings started in January of 1986. The windshear alert, in combination with a data recording system was installed on an in-service 737-300 airplane and data recorded and evaluated. This evaluation was completed in June 1986, and the results validated the current windshear alert design thresholds.

Guidance - The Flight Director

The flight director was chosen as the guidance system because it is simple, has universal applicability, and is displayed on the ADI. Since severe windshear encounters are infrequent, utilizing the flight director rather than some new or specialized instrument is considered the appropriate choice. Pilots use the flight director on a routine basis, are familiar with it, and can apply normal flight director flying techniques to optimize flight performance in a windshear condition. With the flight director on the ADI, instrument scan needs are optimized.

The flight director control laws have been modified to be applicable to windshear recovery after liftoff and go-around. By making modifications to the implementation and ON/OFF switching, the flight director can be available quickly to the pilot even if it was not in use prior to the encounter. Additionally, the flight director can be designed to provide guidance which is similar to the *manual* procedure being taught to flight crews for recovery from an inadvertent windshear encounter. The control laws used by the flight director very nearly duplicate this manual method. The manual procedure was developed during investigation of several accidents. It was determined that the typical pilot can, with adequate practice, properly fly this procedure. For those who have been taught the manual procedure, the flight director will be a similar aid that will give guidance to optimize manually flown procedures.

The takeoff and go-around control laws for the flight director reside in the Flight Control Computer (FCC). For inadvertent windshear encounters within the performance capability of the airplane, the control laws aid the pilot in coping with windshear after lift-off on takeoff and during go-around. The control laws provide flight path guidance and stall protection that become enabled if the airplane climb rate falls below a pre-selected threshold. During takeoff and go-around, if the rate of climb deteriorates, the guidance switches from speed mode to a pitch attitude mode to improve the flight path.

In most wind conditions, this mode will protect the airplanes flight path. However, in severe windshear, if airspeed approaches the stick shaker speed, the flight director switches to the *alpha-margin* mode to provide guidance that maintains adequate stall margins. When the airplane departs the windshear environment, the flight director will smoothly transition back to the normal takeoff or go-around mode. These enhancements are part of the basic flight director control laws and require no unique action on the part of the crew to enable them.

A new feature has been added to enable flight director guidance by pilot activation of the takeoff/go-around switches even when the flight director is not engaged. This provides the crew immediate access to windshear guidance for those circumstances when the flight director is not being used. Following such use, the flight director is reset by cycling the flight director OFF/ON switches.

Pitch Limit Indicator

Because recovery procedures may require the pilot to operate at airspeeds close to stick shaker actuation, the stick shaker may intermittently activate in gusty wind conditions. Discussions with pilots who have flown windshear simulations indicate a reluctance to fly at very low airspeeds due to their inability to judge how close to stickshaker actuation they were actually flying. To overcome this reluctance and to give an indication of where stick shaker would activate, a Pitch Limit Indicator (PLI) was devised that continuously displays margin to stick shaker on the EADI. The distance between the PLI and airplane symbol on the EADI represents the pitch margin between the current flight condition and the stick shaker activation point. The PLI allows a more precise manual procedure to be flown because the pilot is always aware of his proximity to stick shaker activation. When the flight director is in use, the PLI provides a verification of the flight director commands.

The control laws for the PLI reside in the stall warning computer. An EADI is required to display the PLI. Thus, the PLI is only provided on airplanes equipped with electronic flight instruments (EFIS). The PLI is displayed in flight only when the flaps are extended.

CURRENT TECHNOLOGY - OTHER MANUFACTURERS

Other manufacturers have also developed and marketed windshear alerting and guidance systems. The Sperry alert/guidance system is currently in regular airline operational use aboard Peidmont Airlines' Boeing 737 airplanes. The Safe Flight Instrument Corporation is marketing a windshear alert/guidance system and the primary applications so far are in the business jet field. Boeing and Safe Flight have cross-licensing agreements allowing each to use the other's patents in the areas of windshear detection, alert and recovery guidance. Sundstrand Data Control Inc. and Flight Dynamics Inc., have also developed windshear alerting and guidance cockpit aids and are actively marketing these. The Flight Dynamics system is unique in that alerting and guidance information are provided on a head-up display (HUD) device.

FUTURE TECHNOLOGY

Research aimed towards the development of advanced airborne alerting and guidance systems is currently in progress both within industry and NASA. The development of predictive look-ahead windshear alerting systems has the greatest potential for reducing the windshear hazard. These systems, if their effectiveness can be demonstrated within the cost/weight/size constraints of an airborne system, will detect windshear ahead of the airplane, thus significantly improving the capability to AVOID. Research also continues into advanced winshear guidance and cockpit display systems.

Airborne Doppler radar, lasers and infrared devices are among the most promising technqiues for an effective look-ahead windshear alert. Doppler radar capability to directly measure wind speed differentials is well established, particularly in situations where rain is present. However, the capability of Doppler radar to perform effectively on a moving platform, with ground clutter present, has yet to be demonstrated. Another significant design challenge is to integrate this system within the cost/weight/size constraints of the airplane. Laser devices perform best in a clear dry air environment and have degraded capability in heavy rain. Their size and weight is more compatible with an airborne installation, but their range may have to be limited due to eye safety considerations. Infrared systems are designed to detect temperature changes that are associated with microburst windshear. Prototype systems are being proposed for airborne evaluation. All three concepts have their strong points as well as weaknesses. It may well be that the most effective system will employ elements from each.

Current generation guidance systems have demonstrated capabilities that are within 95% of what is considered theoretically possible. Advanced guidance schemes are expected to improve that performance even further. Development of more advanced display systems including flight path angle information should improve the man/machine interaction that is considered so vital to success in a highly stressful, short duration event such as a windshear encounter.

SUMMARY

To supplement the windshear training and to increase its effectiveness, The Boeing Company has developed, certified, and is delivering windshear cockpit systems for its in-production commercial transports. These cockpit systems alert the crew once a windshear is encountered and provide pitch guidance during the recovery maneuver. On airplanes equipped with electronic flight instruments, a visual indication of pitch attitude margin to stick shaker warning is also provided. Other manufacturers such as Sperry, Safe Flight, Sundstrand and Flight Dynamics have developed and marketed their own systems designed to provide effective alerting and guidance. Research activity is well underway to develop advanced alerting systems, capable of warning the crew well before the windshear is actually encountered. Improvements in guidance and cockpit displays are also being investigated.

SUMMARY

Windshear encounters are an infrequent but highly significant hazard to aircraft during takeoff or landing. AVOIDANCE of the hazard is the first line of defense against low altitude windshear. At the present time, avoidance is not always effective, therefore not all encounters can be avoided. With this in mind, two developments can lead to near term improvement in operational safety; enhanced crew training and enhanced systems. In the near term the focus must be on the flight deck. More effective crew training as well as systems that alert the crew to windshear and enhance their ability to escape by providing flight guidance, can improve the outcome of the inadvertent windshear encounter. Future technology developments, particularly in the area of look-ahead airborne windshear alert systems, have the potential for providing another significant improvement in safety. These systems are designed to detect windshear well in advance of the airplane, thus significantly improving the capability to AVOID it.

The Boeing Company is a strong industry partner in the development of technologies aimed at reducing the hazards of windshear. Boeing took the initiative in developing a comprehensive windshear training program as well as windshear cockpit aids designed to improve the effectiveness of this training. Future activities include active support of research designed to produce look-ahead airborne windshear alert systems. Boeing also continues to support and endorse FAA development of improved ground-based windshear detection systems such as the Terminal Doppler Weather Radar (TDWR) and the improved Low Level Windshear Alert System (LLWAS), as well as more effective methods to utilize existing radars which can provide valuable clues to the presence of windshear.

These activities, both within Boeing and industry in general, represent a comprehensive effort to improve operational safety as it relates to windshear.

Mr. **Oberstar**. Our next witnesses are Mr. Gordon Bethune, Senior Vice President for Operations at Piedmont Airlines; and Captain Jim Sifford, Director of Flight Training, also for Piedmont.

Raise your right hand. Do you solemnly swear that the testimony you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. **Bethune**. I do.

Mr. **Sifford**. I do.

Mr. **Oberstar**. Thank you. Gentlemen, welcome to the subcommittee hearing. We look forward to the testimony which you have prepared to shed further light from the practical side of aviation on wind shear and microburst detection systems and their application as well as pilot training and preparation for not only detection and recognition of, but dealing with those weather phenomena.

TESTIMONY OF GORDON BETHUNE, SENIOR VICE PRESIDENT FOR OPERATIONS, PIEDMONT AIRLINES, ACCOMPANIED BY JIM SIFFORD, DIRECTOR, FLIGHT TRAINING

Mr. **Bethune**. Mr. Chairman, distinguished committee members, I want to thank you for the opportunity to appear before you today to participate in this important discussion on wind shear.

Piedmont takes great pride in its reputation of being in the forefront of those who place a special emphasis on safety in air transportation. That emphasis led us to be the first airline in the world to be certified by the Federal Aviation Administration to use a wind shear detection and alert system on its aircraft. As you may know, Piedmont was also the first airline to put into use the traffic alert and collision avoidance system, better known as TCAS, in its normal flight operations. And we are proud to say that neither device was installed because the Government ordered us to do so. They were installed because we thought they would enhance the safety of our aircraft and provide our customers with the kind of air transportation they deserve.

After working for years with industry associations, manufacturers, and FAA on examining the nature of wind shear, we concluded in 1985 that a wind shear detection and alert system developed by Sperry Corporation could provide important safety benefits. We engaged in a testing program in conjunction with Sperry and the FAA and, following FAA certification, began installation of the system in November of 1985.

At this time, the wind shear system has been installed on fifty-eight of our sixty-two Boeing 737-200's and our 767-200-ER fleet. It is scheduled for implementation on five of our 727-200's, our thirty Boeing 737-300's, and all future deliveries of 737-300 and 400 and 767 aircraft.

We have been pleased with the performance of the system. The onboard wind shear system offers an extra safety edge over ground-based detection systems, such as the Doppler weather radar, because it is always with the aircraft. The cockpit alert system can detect a wind shear before it becomes apparent to a flight crew from normal instrument scan, and gives the pilot valuable time to take corrective action.

Over the course of the past year and a half, according to our log on the wind shear system, the system has been activated thirteen times. Ten of those activations were determined to be valid, and in one instance in particular the system clearly enabled us to avoid a potentially very hazardous situation. We have encountered few problems with the detection device.

Simply installing a system, however, is not enough. Thorough pilot training is an essential ingredient of our wind shear program. Piedmont developed its training program with input from Boeing, who testified earlier, who worked on this subject with the FAA and, of course, United Airlines.

Captain Sifford has tested the wind shear mechanism in flight and is familiar with how the device operates. Mr. Sifford and I would be happy to answer any questions you may have.

Mr. **OBERSTAR**. Thank you very much. We greatly appreciate your presentation and compliment Piedmont on its forward-looking attitude towards safety with both the TCAS and the weather detection concept.

I would like to depart from the issue at hand to ask you about your experience so far with TCAS and how it's working.

Mr. **SIFFORD**. Yes, Mr. Chairman. Captain Womack, with Piedmont, has been a major player in the TCAS program, but I did some initial STC work, supplemental type certificate work, on the aircraft. As far as I know, we're in the stage two or phase two of the program now, and it appears to be going as predicted and quite well, actually. I don't really have a lot of the details because I did not come prepared for that today. But we have had no real adverse comments concerning that.

Mr. **OBERSTAR**. Has the captain who has had the experience with it received alerts and taken avoidance measures?

Mr. **SIFFORD**. I believe I have heard the number of three, and they were not, as I recall it, what you might call close, but there was some activity in moving the aircraft about in its predetermined space.

Mr. **BETHUNE**. Mr. Oberstar, there was a report just most recently, ten days ago, that had the numbers specifically. I didn't bring that with me today. However, it is a test program and as such the alert limits are now being defined. So there is, as was stated earlier, the concern about false alerts and the nuisance value.

I think generally we are pleased with the value of the system. We have demonstrated conceptually that it is working and can be applied, but whether it has all the values defined as we would like to put them into operation, I don't think we're there yet. We are still very positive about the TCAS II system and think that it has a lot of applications in aviation.

Mr. **OBERSTAR**. Thank you. We won't dwell on that, but we will have a hearing to receive a progress report on the status of Piedmont's experiment with it. We compliment you for being involved.

Captain, how many years have you been flying?

Mr. **SIFFORD**. Well, I have been with Piedmont about twenty-two years, but almost thirty years now for a living. In 1989 it will be thirty years flying for a living, sir.

Mr. **OBERSTAR**. You look too young to be flying that long.

[Laughter.]

Mr. **Sifford**. Well, thank you very much. That's a nice compliment.

Mr. **Oberstar**. Have you during your flying years personally encountered wind shear?

Mr. **Sifford**. Yes, I have encountered wind shear. I don't think I have encountered wind shear to the magnitude that we're talking today, but we've certainly had deviations in airspeed, ten knots, fifteen knots, sometimes twenty knots. But I haven't had a wind shear activity that I would consider dangerous by the standards we're talking about today. Certainly nothing close to the ground.

Mr. **Oberstar**. What do you think is the frequency of pilot experience with wind shear, and is your experience fairly typical?

Mr. **Sifford**. Well, we heard previous testimony. I think someone mentioned thirty years. I have heard two other numbers. One was eleven years and one was eighteen years. Now, where these statistics come from, I really don't know how they were put together. But, of course, there is wind shear. I think in earlier days before wind shear became such an issue and before technology and research is to the stage it is today, we called it sinkers or we called it sinkholes. We had other names for it, but indeed it was wind shear. It just wasn't called that until probably in the mid-1970's, late 1970's.

Mr. **Oberstar**. Now that we know more about it, we have better technology to detect it, we're able to more precisely define and describe it. But it was testimony before this subcommittee by a pilot from another airline who said, "I only experienced it once in thirty years, and I don't ever want to have that experience again."

Mr. **Sifford**. That's true. I don't want to ever have it either.

We have had quite a few technological breakthroughs; radar, as an example. In earlier years we had no radar, no weather radar, prior to my coming to the airline on the equipment that I flew. So that in itself has been a great advantage to wind shear because especially at airports without a radar environment and no radar onboard the aircraft. So that was one of the things that I saw in my career that helped detect the factors of thunderstorm there at the airport. So that in itself was a breakthrough.

Mr. **Oberstar**. Have you had simulator training for experience with wind shear?

Mr. **Sifford**. Quite a bit of simulator training. My first experience was at the Boeing Aircraft Company about, I guess, almost two years ago during some research and development work there that I participated in. It was quite enlightening. And since then, of course, at Piedmont we've had training there and proficiency checks and that type thing.

Mr. **Oberstar**. Mr. Bethune, does Piedmont have its own simulator?

Mr. **Bethune**. Yes, sir, we do. We today own five simulators, with another on order.

You asked earlier about the costs. I wish they only did cost $3 million. They're closer to $7 million, Mr. Oberstar. They are expensive devices, but the alternatives are more expensive.

Mr. **Oberstar**. Well, we certainly appreciate that attitude on the part of Piedmont. I think it's good to know that you are making that kind of investment in safety and are willing to invest dollars of that magnitude. We certainly do compliment you. I feel a whole lot better about paying my next ticket price on a Piedmont flight. [Laughter.]

How often or what is the frequency of pilot training on simulators?

Mr. **Bethune**. Well, each captain has to undergo two simulator checks a year; first officers, I believe, once a year. Of course, when you type-rate or you do your initial training, there is an exhaustive curriculum that initially acquaints you and type rates you on the aircraft. But on a recurrent basis it's twice a year for our captains and once a year for our first officers. And each of those sessions then would have a wind shear encounter. I believe Captain Sifford can tell you about the different mix of wind shear encounters that we can provide using simulators duplicating accidents that have already been documented, the Pan American New Orleans type of encounter. So that our pilots become comfortable with—not comfortable, but at least familiar with the symptoms of approaching wind shear conditions and what to do when you're in them.

Mr. **Oberstar**. Does your training program, Captain Sifford, replicate both takeoff and landing wind shear phenomena?

Mr. **Sifford**. Yes, we do. We have the New Orleans, the one that was mentioned previously. That one is in there, and as well we have the classic one, if you will—it has been called that, I suppose—the one at Salt Lake. I believe we have the Kennedy, the Philadelphia, the Dallas. And since those, we have actually bought from one of the simulator manufacturers a model of a wind shear that is a movable wind shear, if you will, and it can be moved around to different places on the final approach and it can be put—the ones we saw today are all the very classic, upside-down mushroom, if you will.

Mr. **Oberstar**. Yes.

Mr. **Sifford**. There is also the wind shear condition where it's just off the center line of the runway so you'd hit a different edge and not go through the center part. So this is being purchased and installed from one of the simulator manufacturers. So we have taken on our own to put that one in. It's a movable one with a movable shaft.

Mr. **Oberstar**. Does that also give you experience with the asymmetrical wind shear phenomena?

Mr. **Sifford**. It would be possible to set that one up in that condition; that's correct. The other models we have are at the best estimation of the wind shear activity was present during the accidents at the major airports we've mentioned.

Mr. **Oberstar**. You heard the description from our Boeing witness about the pilot who sensed, even though he had been told that there was no wind shear activity in the TCA, that he just sensed at the 300-foot level that there was something wrong. He had had the training, and he was prepared to respond to that, and did successfully.

How much training does it take to get to that point? Just one experience? I mean, I have been in a simulator, I have seen how it operates. I am not a pilot, so I couldn't put myself in that pilot's position. But when he went through that experience, he was perspiring in his back and under his arms and around his neck, and he lived that experience as though we were out there in that weather. Now, is one of those experiences sufficient, or do you have to repeat that training several times?

Mr. SIFFORD. I believe that some of the feeling that probably preceded the visual indications would have been the body reacting much as one of the sensors may react in an onboard wind shear system. The inertial factor, the G's on the body, that type thing would probably have preceded the actual visual instruments, for example, the rate-of-descent indicator flattening out or the airspeed shift or that kind of a thing. So I believe in some cases it's recognizable there, and this really can't be produced in a simulator, that part. We can give in a simulator the classic airspeed needle shift, the flattening out of the rate of climb. That kind of a thing we can duplicate in a simulator.

So I think probably the first thing you would see in the simulator would be this deviation of the various needles or the instruments.

Mr. OBERSTAR. What is the most important lesson you learn from your simulator training?

Mr. SIFFORD. I believe the most important lesson is, as was testified earlier by Boeing, the first encounter I had was on a takeoff encounter, and I think all my career we had been taught not to go below this reference speed for takeoff, which is twenty percent above the stall speed. It's V-2 speed.

We had been told not to go below the bug. Yet, just after liftoff, when you encounter the wind shear, you see the rate of climb going down, you're going towards the ground, the airspeed is starting to drop back toward the bug or below, and I think everything in your body says, "No, you don't want the airspeed below the bug," so you have a tendency not to pull back. And as was testified to earlier, there are some stick forces there that are uncommon. It's a stick force that is uncommon to what would be natural during takeoff because the stabilizer trim is already set for takeoff speed.

So that is probably the thing that you learn. You have to teach the person to come back to a higher deck angle, although your airspeed is decaying. So I think that is probably the lesson that I learned in this maneuver more than anything else.

Mr. OBERSTAR. The trade-off between speed and lift.

Mr. SIFFORD. Yes. That's correct.

Mr. OBERSTAR. And knowing which is important at what time.

Mr. SIFFORD. Yes. That's very important. As a matter of fact, the first time I tried, I crashed the simulator on takeoff. You know, it took the second time before I got it. So it was that critical to me.

Mr. OBERSTAR. Mr. Bethune, could you describe for us the incident which you referred to in your testimony, in which because of the training, the pilot was able to avoid a potentially catastrophic wind shear? When did that occur?

Mr. BETHUNE. I believe, sir, that was November 19, 1985, which by the way is the initial day of service for our operational use of the wind shear. It was on approach to Chicago. Captain Sifford is much more knowledgeable about the actual flight. But it was our first day operating the wind shear equipment when we believed that we had in Chicago a valid wind shear warning and the captain executed a missed approach.

Mr. **Oberstar**. Would you describe that for us, please?

Mr. **Sifford**. Yes, indeed. It was almost as ironic, I think, as the one we heard about in Atlanta shortly a while back. We were very excited about it. The 737 left Greensboro, where it was based. The equipment had been installed the previous night. It had finished its day's work almost. It wound up in Chicago sometime about 6 or 7 in the evening. This was the first day of operation with the wind shear detector onboard.

Wind shear was reported by the tower. The pilot was aware of wind shear activity via the ATC system. At about—wind shear activity was reported at about a thousand feet, and about twelve hundred feet the pilot—he told me this himself—the pilot had said, "Well, I was just getting ready to go around. I thought, well, this is getting rough, this is about enough." So, he said he was just getting ready to go around when the red light or the warning system came on and announced, "Wind shear. Wind shear. Wind shear."

He said, "You know, that fortified my decision to go." So that's when he began the go-around maneuver, and even with the go-around at approximately eleven hundred feet, eleven to twelve hundred feet, even at that altitude, he drifted down to almost two hundred feet of the ground. He was pretty close to two hundred feet.

So I think that one experience at Piedmont Airlines was certainly enough to convince us if we had any doubts at all. And with two other pilots that I have talked to that actually had the warnings, the hard warnings, as we say, or the red, not just the caution but the actual warning itself, three of the pilots I have talked to personally that had the warning, the first one I just described, the other two pilots did in fact execute a missed approach.

I thought it was ironic that both of those pilots indicated to me that they said, "We were just getting ready to miss the approach. Then the light came on." So I think that was the final trigger that by that time they had everything they needed to make the decision to go. And, yes, it's reactive system, they were into a wind shear system, of course, when it went off. It's not predictive. But you know, that was a decision whether we're talking about one second, a millisecond, three seconds, it fortified his decision to get out of there. So I think that's what it's all about.

Mr. **Oberstar**. You are being paid to execute judgment.

Mr. **Sifford**. Yes.

Mr. **Oberstar**. And it's in that millisecond you exercise the right judgment that saves, what, one hundred thirty lives?

Mr. **Sifford**. Well, I think the first one, like I said, that really let us know we made the proper decision, I think. I certainly wouldn't say that was a save, but I would say that we were definitely much better that the system was onboard.

Mr. **Oberstar**. The basic message that I get through all the testimony so far is: don't challenge the weather; get out.

Mr. **Sifford**. Stay away from it. That's absolutely the best way. But, then, as we said earlier, it's not quite so simple just to stay away because we do fly through wind shears of the magnitude of five knots or ten knots or twenty knots. You know, there are wind shears there, and we have to transverse some. Now, how serious are they, I guess that is really to me the bottom line: how serious is this wind shear that we're going to fly through? We have wind shears on March days, you know.

Mr. OBERSTAR. What percentage of pilots going through simulator training fail on their first attempt?

Mr. SIFFORD. I really couldn't tell you that. The particular one I was in, there were, I think, four people looking over my shoulder. So after they went to school on me, they flew it out, I know that for sure. [Laughter.]

I suppose that—well, I would suppose twenty percent or thirty percent because in a general case they're well prepared through the tapes, especially the FAA tape which we found quite good, actually, and the Boeing tape that is being implemented into training at this time. So that is preparatory to going into the simulator. So most of the people know exactly what to expect; it's just a matter of their mind knows what to do, now their hands have to be taught or the motor skills have to be developed to do this maneuver. So it's not quite as high a rate as one may think.

Mr. OBERSTAR. Well, all that training is just so critical. I can recall testimony two years ago at our hearings on other aviation problems, about—well, this one was on runway incursions, and you may well be aware of the incident in March of 1985 of two DC-10's at Minneapolis-St. Paul Airport where one was taxiing after landing and the other one was on its takeoff roll, at right angles with each other, and other parked aircraft loaded, other DC-10's and 747's, and bad snow conditions. Always those things happen when you have the worst weather.

The two had been cleared for a collision course by the tower, and the pilot of the takeoff aircraft had just completed a training program on the reserve power of those powerplants on the DC-10, and he knew that he could take off at just below the speed at which he had been accustomed to doing. In that split second, he made that decision and missed the other aircraft by fifty feet. It could have been civil aviation's worst disaster.

So you folks on the front line of training, it's easy to say that, but it's so critical, it's so important in those microseconds that you have to make those decisions.

The gentleman from Pennsylvania?

Mr. CLINGER. Thank you, Mr. Chairman.

In recovering from a wind shear episode, can it only be done manually or can an automatic pilot be utilized in recovering?

Mr. SIFFORD. It depends on the installation. There are autopilots that would be available to do that that would fly that maneuver. The equipment that we retrofitted to the older aircraft—you have to understand that one of the aircraft that we have is almost nineteen years old that we put this on. So it's a retrofit, and it indeed has the guidance through the flight director. And we chose not to go through the autopilot on it.

One, it would have been terribly expensive. And quite honestly, I don't believe that many pilots, given the fact that they're going to do this maneuver once in a lifetime, once every eleven years—your numbers are as good as mine—but given the fact that this serious condition is going to happen, I do not believe that the average line pilot would continue with the autopilot. He would disconnect it.

Mr. **Clinger**. He would want to be in command of his own destiny in something as serious as this.

Mr. **Sifford**. Yes. Because it's one thing for an instructor pilot or a test pilot or the various and sundry people that you normally talk with to do one matter, but when the line pilot, the guy in the trenches on the Saturday nights in Chicago at 11, you know, when he gets into this situation, he's kind of on his own. And I think most of us would revert back to manual flying, probably, and disregard the autopilot. Yet I do believe we would follow the guidance system.

Mr. **Clinger**. Yes.

Mr. **Sifford**. We chose to put it on the flight director. There are several different systems available, but the pilot normally flies the flight director. One of our first goals was to put it on an instrument to be used every day, and the flight director in our case is used, I would say, ninety-eight percent of the time by the pilots. So if he gets in a wind shear condition, he goes to an instrument that he is very, very familiar with, that being the flight director.

We enunciated it with the clear commands, "Wind shear. Wind shear. Wind shear." We also chose to put in a caution system, which was very controversial. There were some schools of thought that this was not necessary. It was our thought that it was necessary. So that's the approach we've taken to it.

Mr. **Clinger**. When you get the warning, "Wind shear, Wind shear, Wind shear," you're in it at that point; right?

Mr. **Sifford**. Yes.

Mr. **Clinger**. This is not preparatory, this is not prior to entering it?

Mr. **Sifford**. Well, it's, I would say, on the very edge. There again, there are thresholds set for this condition, and as was mentioned earlier, the real trick is to not "cry wolf" but to indeed have the pilot develop confidence. It was a system put on aircraft much earlier in ground products.

There were some problems with the airports, and it was lacking confidence for some time until the thresholds were changed and there were certain things changed. So we certainly want to get into a condition of having this thing. We don't mind a guy missing an approach occasionally, but we want him to trust it and in fact miss the approach when necessary.

Mr. **Clinger**. Speaking of crying wolf, we have heard from other sources that pilots have less than total confidence in the LLWAS system, primarily because of the high incidence of false alarms. Is that true of pilots generally, would you say? Or, how about Piedmont pilots, how do you feel about the LLWAS system?

Mr. **Sifford**. I was very encouraged today to hear that the system is being improved to give a pilot more information. I think, in my opinion, really the critical time on wind shear is the last minute and a half before you land, if you assume that the last minute and a half you're going to be about a thousand feet above the ground or maybe seven hundred fifty feet.

So as I perceive this, you have about ninety seconds before landing, you're in a critical situation, and probably the same ninety seconds after takeoff. If you're prior to that point, you would have a much better chance of escaping a wind shear condition. If you miss the approach, you come around and you land after a while or you land tomorrow; you just don't get into that. So the ninety seconds immediately before is a critical period of time.

I think the pilots perceive this as a good procedure as far as the pull-up procedure, the same problem there.

Mr. CLINGER. And do you?

Mr. SIFFORD. Yes. But the entire problem has been—I'm sorry, the last ninety seconds of the approach with a low-level wind shear system, if you happen to be one minute out or forty-five seconds out and you still have glide slope information to observe not to get below that, you're watching airspeeds, you're coordinating other things as necessary. And if a person tells me that the mid winds are two hundred eighty at twenty-one knots and the northeast winds are another—there is really too much information to be processed that quick, or in my case there certainly is. And that is the negative comments that I have heard about the low-level system. But it's far superior to anything we have on the ground.

I have used it in Dayton on two occasions when we had wind shear reported by that system, and it was a low-level twelve, fifteen-knot shear, and there was no bad consequence on the approach. But there again it's not to say it wasn't there, it just meant, as we had earlier testimony today, the microburst had moved. It was a very brief encounter there evidently.

Mr. CLINGER. From your perspective, from a pilot's perspective, what would you say was the best means of transmitting ground-based weather information from the ground to the pilot?

Mr. SIFFORD. In the wind shear case, of course, you're referring to?

Mr. CLINGER. Yes.

Mr. SIFFORD. I really don't know a good way to do that. I suppose if there were a data link system——

Mr. CLINGER. You mean, now if it comes at all, it comes through the controller, does it not?

Mr. SIFFORD. Well, I think, as was earlier testified to, if the controller has the information given to him and he can tell you that the wind shear is at six hundred feet on final to runway to 36 left, that's all I need. But that technology would certainly have to furnish him with that information because, while not being a controller, I would assume that he would have the same difficulty in trying to interpret instruments or anomometers or this type thing. He would have to have some sort of a quick reference himself because of the short duration of some of the microbursts.

So he would have to, one, be given the information rapidly, and then, in turn, give it to the pilot rapidly if it was an aural. But if he could just tell the pilot it's at eight hundred feet on final, that takes maybe three seconds and that's the end of it. But short of having that type information, it would be some delay, I would guess.

Mr. CLINGER. We talked earlier about integrating ground-based information with what ultimately may be developed as far as airborne information in an overall package which the pilot would have available. Is it better to have it come to you verbally from somebody warning you about what the situation is, or for you to assimilate yourself from onboard monitors or CRT's or whatever?

Mr. SIFFORD. Well, I prefer the onboard system, personally. But there again, technology—and I guess I would like to see someone's idea on whether it would be an aural alert through an uplink via data mode or whether it would be on a map display such as a glass cockpit. There are several ways to deliver it to the pilot.

Mr. CLINGER. But you personally would prefer some sort of onboard system?

Mr. SIFFORD. I prefer an onboard system, personally.

Mr. CLINGER. Thank you, Mr. Chairman.

Thank you, gentlemen.

Mr. OBERSTAR. Picking up at that point, the previous testimony indicated that airborne systems for weather detection are some time off into the future in terms of effectiveness and capability and because of problems of downsizing those systems to put them onboard aircraft. If that's the case, then how much more important is the uplinking of information developed on the ground?

Do you feel comfortable with the pace of movement on the technological development that you have heard so far today on LLWAS, on NEXRAD, and the Doppler system?

Mr. SIFFORD. Well, I certainly support those programs. I think there has been an awful lot of work done on them. I think there has been a lot of good spinoffs from them. But, I guess, as mentioned earlier, I believe, by yourself when we talked about the second tier of airports, the second one hundred to the third one hundred, Piedmont operates a rather extensive shuttle system through Florida that's known as the Piedmont Shuttle, and I suppose I have concerns about Key West, Florida; Naples, Florida; Kingston, North Carolina; Jacksonville, North Carolina, just to name some of the smaller airports. I don't really know when we would get to that level of airports. And they have the Beech 99, someone mentioned. They have general aviation. There are many different kinds of airplanes.

Some of the airports in the United States today operated by 121 operators that are still lacking a control tower; there is no approach control; there is, in some cases, no VASI system.

My question, then, is I don't know just exactly when we would be able to get these at the airports. But if we have it onboard the airplane, it goes to the airports with us. So that's my view.

Mr. OBERSTAR. You would feel most comfortable with an airborne system. That would give you the highest level of confidence?

Mr. SIFFORD. Yes. I am not opposed to the ground system, provided——

Mr. OBERSTAR. No, no, that's not the question. The question is what do you feel most comfortable with, what gives you the greatest sense of security? And as you said just now—I think you put it very succinctly—an airborne system, you carry with you, it goes into every airport.

Mr. SIFFORD. That's right. It's there. And you see, it's not unusual either, because like today, if we go from Washington, D.C., to some other State or country, we have our own airborne weather radar, we detour thunderstorms, we do that type thing, and really no help at all from the ground. We carry it with us. We have a ground-proximity warning on the airplane we carry with us. We're not dependent. And this could easily be done through certain ground-based equipment to warn that you're too low, and is in some of the approach centers today.

So many of the things we carry with us, and it seems to be that they are very satisfactory.

Mr. OBERSTAR. You would then, given that viewpoint—and I think it's most understandable—would like to encourage, I would assume, more research and development of dependable airborne systems?

Mr. SIFFORD. Absolutely.

Mr. OBERSTAR. How much advance warning do you think ought to be given for pilots on either takeoff or landing, but especially on landing? What is the time frame, shortest-period time frame in which you need information to be able to react, considering also how much maneuvering room you have in the TCA once you've entered it?

Mr. SIFFORD. Well, as I stated earlier, a rough speed of two miles a minute, one hundred twenty knots, two miles a minute, a minute and a half before landing you're still at a thousand-plus feet in the general case. You're at 1,200 feet, and I am sure there are gentlemen here who are more knowledgeable on just exactly how much loss would be expected. But I am not sure that many losses would occur in a severe case much more than a thousand feet. But that is certainly—I really don't know the number there. But I would feel comfortable, from what I know about wind shear, that you could execute a maneuver from 1,200 feet, which would be roughly ninety seconds or a minute and forty-five, let's say.

Mr. OBERSTAR. So that's the point, you would use a yardstick more of altitude and airspeed than time frame ahead?

Mr. SIFFORD. Well, time in as that means altitude to me. If I have a wind shear at two thousand feet, I am not so likely to hit the ground, you see. But if I'm at a thousand feet, then it's a little bit closer. So from that perspective, I go by altitude equals time to me in the escape maneuver.

Mr. OBERSTAR. Three hundred feet is——

Mr. SIFFORD. Too low. [Laughter.]

Which is not very much in time, either.

Mr. OBERSTAR. Does Piedmont maintain a staff of weather dispatchers?

Mr. BETHUNE. We have a commercial weather system available, and of course a full-scale dispatch office with licensed dispatchers on duty at all times. So, yes, sir, we are self-sufficient.

Mr. OBERSTAR. If Captain Sifford is taking a flight from point A to point B, what is the advance time weather that he gets? How current is the information he gets prior to takeoff?

Mr. BETHUNE. We have all the Government sources of weather available to us in the dispatch center, as well as a commercial real-time radar system that can call up by city specifically real-time information to base either routing judgments with or discuss with the crew. It's not a question of having the accurate information available to do proper flight planning or to assess whether it's a go or no-go situation.

Mr. **Oberstar**. So it's real-time information right now with what the situation is here and enroute and at destination?

Mr. **Bethune**. It is commercially available, yes, sir.

Mr. **Oberstar**. Does that information overlap with the flight service stations of the FAA?

Mr. **Bethune**. As I said, we do use the Government information and corroborate that with—and it is sometimes an individual decision between the crew and the dispatcher what is the best route of flight, given the weather conditions on the flight path. So it's a licensed FAA-approved system that we use with good success.

Mr. **Oberstar**. I have been in the briefing center of one of the other major airlines and seen all the various information available for pilots. I must say it was my first experience—this was some years ago—it was my first experience and first understanding that pilots have to be meteorologists. [Laughter.]

You really have to know a great deal about weather. It was an eye-opening experience for me. Therefore, weather forecasting services become extremely important in getting that information as current as possible.

How about the pilots, how frequently do you send information out and disseminate it within your system, within the Piedmont system?

Mr. **Sifford**. The pilot reports are normally given if the dispatcher learns of some condition such as an icing condition, a slippery runway, a tornado, severe weather, if he learns of severe weather, we have the capability of calling the aircraft. We have a system known as ACARS, as the acronym, which is an uplink system that we have today. We put that on in 1975. And we can send a message directly to the airplane from the dispatcher and give him this message, or voice communications. In the general case, though, it's done by air traffic control with the tower.

Mr. **Oberstar**. What does an airborne weather system fail to detect? What information don't you get that you feel you need?

Mr. **Sifford**. I'm sorry?

Mr. **Oberstar**. With a weather radar system.

Mr. **Sifford**. Airborne?

Mr. **Oberstar**. Yes.

Mr. **Sifford**. The aircraft's radar?

Mr. **Oberstar**. Yes.

Mr. **Sifford**. Well, all of our radars have been modified to the latest Bendix. They have the turbulence detection on them. It's the color. And of course, the turbulence can only work if there is moisture, as I understand the principle of this radar. There has to be moisture there before it can work. So it's a Doppler of a sort. In fact, I guess it is Doppler radar.

Mr. **Bethune**. I think, Mr. Oberstar, for the technology, we have all the technology that is commercially available in our aircraft today. If I have heard a common complaint, it would be that the radar's penetration ability through a weather system or a front leads you sometimes to believe that behind whatever you're about to penetrate there is clear air, when in fact the radar is unable to go ahead with the distance or the power to discern that there is more and worse behind what you are presently on course to intercept. That is a common complaint.

However, today's technology with airborne radar systems is night-and-day difference from what it has been in the last twenty years or, like Captain Sifford says, before there was a radar.

We feel comfortable with the systems that we have, but obviously we would like them to be better.

Mr. **Sifford**. And we have made modifications. As I say, we had some of the problem, and we have changed mods in the past two years, I would say. We have recent modification, different dash number radars.

Mr. **Oberstar**. Thank you. That is the kind of information I was looking for.

A final question. I know that there is in the works an impending acquisition or merger between USAir and Piedmont. What effect is that likely to have on your safety program, which seems to me very, very much advanced?

Mr. **Bethune**. Well, I would think we would complement each other. USAir, of course, has a very fine safety program. We made a major investment in a type of equipment, 737-200, because of the scale we operated, sixty-three, sixty-two of the airplanes. I would—we have not made those decisions as far as commonality of type equipment and the cockpit layouts. But that is on the agenda, and I would surmise that we would extend our program so that it would be common across the combined fleets.

So by osmosis or otherwise, I think we will extend our onboard wind shear detection systems into the USAir fleet if for no other reason than for cockpit commonality. It's logical. I can't say that with certainty, although I have no reason to believe that wouldn't be the case.

Mr. **Oberstar**. Very good. Let us hope that you are, in the new configuration, able to maintain the momentum already initiated.

Is there any other comment that you would like to make, any other thing that comes to mind?

Mr. **Sifford**. I would like to thank you for the opportunity to come and address your committee today.

Mr. **Oberstar**. Well, we thank you very much for the contribution you have made and the information you have provided us. It will be very useful in developing the picture we want to present to the public on aviation safety and the relationship of safety and weather and the response of the airlines to that situation.

Thank you very much for your presentation.

Mr. **Bethune**. Thank you, sir.

Mr. **Sifford**. Thank you.

[The prepared statement of Mr. Bethune follows:]

TESTIMONY OF GORDON M. BETHUNE
SENIOR VICE PRESIDENT-OPERATIONS
PIEDMONT AVIATION, INC.

Before the Committee on Public Works and Transportation

Subcommittee on Investigations and Oversight

June 30, 1987

Mr. Chairman, and distinguished Committee Members, I am Gordon M. Bethune, Senior Vice President-Operations, of Piedmont Aviation, Inc. I am accompanied by Capt. James C. Sifford, Piedmont's Director of Flight Operations-Technical. I want to thank you for the opportunity to appear before you today to participate in this important discussion on windshear.

Piedmont takes great pride in its reputation of being in the forefront of those who place a special emphasis on safety in air transportation. That emphasis led us to be the first airline in the world to be certified by the Federal Aviation Administration (FAA) to use a windshear detection and alert system on its aircraft. As you may know, Piedmont was also the first airline to put into use the Traffic Alert and Collision Avoidance System, better known as TCAS, in its normal flight operations. And we are proud to say that neither device was installed because the government ordered us to do so. They were installed because we thought they would enhance the safety of our aircraft, and provide our customers with the kind of air transportation they deserve.

After working for years with industry associations, manufacturers, and FAA in examining the nature of windshear, we concluded in 1985 that a windshear detection and alert system developed by Sperry could provide important safety benefits. We engaged in a testing program in conjunction with Sperry and FAA, and, following FAA certification, began installation of the system in November of 1985.

The system was incorporated into our aircraft's Performance Management System (PMS). The PMS is another technological advance in which Piedmont has invested. It is a computerized system that computes, displays, and flies the aircraft automatically at best engine performance and air speed for maximum economy for the complete vertical profile and horizontal regime. In addition, the PMS sends engine data to our maintenance computer system via the ACARS system. PMS was well suited for installation of a windshear system. At this time the windshear system has been installed on fifty-eight of our sixty-two Boeing 737-200s and our 767-200 ER fleet. It is scheduled for implementation on five of our Boeing 727-200s, our thirty Boeing 737-300s, and all future deliveries of our Boeing 737-300s, 737-400s and 767-200 ER aircraft. All of these systems will be look-alike systems and will have full detection, alerting, and guidance capabilities.

Other witnesses here today will no doubt cover the question in detail of how the system works, but allow me to give you a simplified summary.

The windshear detection system has two functions, the detection or "warning" function and the "guidance" function. The warning function of the windshear detection system provides the pilot with a two stage warning of potentially hazardous wind conditions. The system is set to provide warnings at altitudes below 1,500 feet or when the aircraft controls are set in landing or take-off positions. It alerts pilots of an impending windshear condition with an amber light and the message "caution, windshear" is displayed on the performance management indicator (PMI) screen. If a severe windshear condition is encountered, a red warning light flashes, "windshear, warning" is displayed on the PMI screen and a recorded voice repeatedly says "windshear" until the aircraft flies out of the windshear condition or the wind abates.

The windshear detection system also has a computerized "guidance" function which furnishes the pilot with precise information to assist him in exiting a windshear condition should one be encountered. If a shear cannot be avoided, the guidance computer calculates an optimal flight path, providing information through the pitch bar of the flight director. The guidance system also provides information on safe airspeed and altitude after the aircraft exits the turbulent air. The guidance function of the system was certified by the FAA in December of 1986.

We have been pleased with the performance of the system. The on board windshear system offers an extra safety edge over ground based detection systems such as the Doppler weather radar because it is always with the plane. The cockpit alert system can detect a windshear before it becomes apparent to a flight crew from normal instrument scan and gives the pilot valuable time to take corrective action.

Over the course of the past year and a half, according to our log on the windshear system, the system has been activated thirteen times. Ten of the activations were determined to be valid, and, in one instance in particular, the system clearly enabled us to avoid a potentially very hazardous situation.

We have encountered few problems with the detection device. On very rare occasions, the system has activated when there was no apparent connection to turbulent air conditions. However, even when that rarity occurs, the worst result is simply an unplanned go-around. We believe these problems will be eliminated as more experience with the system is obtained.

Simply installing a system, however, is not enough. Thorough pilot training is an essential ingredient of our windshear program. Education is important in dealing with windshear since the techniques for successful recovery from an unexpected windshear encounter may be in conflict with a pilot's intuitive reaction. Piedmont developed its program with input from Boeing, who worked on this subject with the FAA and United Airlines.

Our training emphasizes both windshear recognition and avoidance, as well as recovery techniques from an inadvertent windshear encounter, and stresses crew communications. Crews are taught to avoid known windshear, and how to evaluate weather and conditions so that windshear and its dangers can be recognized. Then there are specific flying techniques which are used when an unexpected windshear is encountered. With these techniques, we can prevent a dangerous flight path from developing. We also emphasize precautionary measures when the probability of windshear is high. For instance runway selection, flap selection, amount of thrust, or extra speed in some cases, are precautions which can improve recovery chances when an unexpected shear is actually encountered. The final component of our windshear program is training in the specific recovery technique which is used when a windshear is actually encountered.

Because near ground shear encounters are relatively rare and a pilot may never encounter one during his career, hands-on simulator training is essential. In 1986 our flight simulators were certified for windshear detection and guidance equipment. We are able to reproduce various take-off and landing windshear conditions, including those encountered in the Dallas, Logan Airport, and New Orleans crashes. All initial pilot simulator training includes several encounters with different types of windshear conditions. This initial training is given to all newly-hired pilots and to those pilots who are being trained to operate another type of aircraft. Simulator training includes training both with and without the computerized detection and guidance functions. In addition, all pilots encounter at least one windshear exercise in their bi-annual simulator checks. We also have a video tape on windshear which each pilot reviews. Pilot acceptance of the windshear system has been excellent.

This gives a broad outline of our windshear program. I have already introduced Captain James Sifford, Director of Flight Operations-Technical for Piedmont. Captain Sifford has tested the windshear mechanism in flight and is familiar with how the device operates. Mr. Sifford and I will be happy to answer any questions you may have.

Mr. **Oberstar**. Our next panel is the General Accounting Office, Mr. Herb McClure, Associate Director, Resources, Community and Economic Development Division at GAO; accompanied by Mr. Arthur Shantz and Mr. Virgil Schroeder.

Gentlemen, thank you very much for being with us.

Please rise and raise your right hand. Do you solemnly swear that the testimony you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. **McLure**. I do.

Mr. **Shantz**. I do.

Mr. **Schroeder**. I do.

Mr. **Oberstar**. Thank you. I would like to express the deep appreciation of the subcommittee to GAO and to members of this panel for helping us to develop over a period of many months the ingredients of this hearing and the significant elements that committee members and staff have been able to bring together to bear on this unique aspect of aviation. It has been a great asset and one of incalculable value in bringing together this hearing. And we thank you for your vigilance and for your expertise that you have brought to bear on this subject.

TESTIMONY OF HERB McLURE, ASSOCIATE DIRECTOR, RESOURCES, COMMUNITY AND ECONOMIC DEVELOPMENT DIVISION, GENERAL ACCOUNTING OFFICE, ACCOMPANIED BY ARTHUR SHANTZ, ASSIGNMENT MANAGER, AND VIRGIL SCHROEDER, EVALUATOR-IN-CHARGE

Mr. **McLure**. Thank you very much. We are happy to be here. I think it has been a very interesting hearing so far. What I will do is try to summarize the things that are contained in our statement that will add to what we have already heard today, with your permission.

We are doing our work on these particular weather systems for the House Science, Space, and Technology Committee, and we are grateful to Chairman McCurdy and the members of the Transportation, Aviation, and Materials Subcommittee for this opportunity to share our findings with you today.

According to FAA, there are two main problems with the existing aviation weather system: inadequate weather detection systems, and the lack of a quick way to communicate weather information to the pilots. To correct these problems, FAA's National Airspace System Plan calls for a billion and a half dollars' worth of new weather systems. Today we will talk about wind shear detection, precipitation and thunderstorm detection, which hasn't been discussed much today, and communicating hazardous-weather information to pilots.

Wind shear, of course, as you have heard about today, has been identified as a cause or a factor in eighteen accidents since 1970 which involved the loss of five hundred and seventy-five lives. As you have also heard, FAA is developing three new ground-based systems to detect wind shears.

In our work, we have found that all three either have detection limitations or some unresolved technical problems. The first system is LLWAS. It is limited by its location, although it's quite an improvement over the previous LLWAS system. Many think the improvements will be very successful.

The second detection system you have heard about today, but not very much about it, is the terminal NEXRAD radar system. It will be capable of seeing wind shears and microbursts as much as thirty miles away from the airport. The radar will be located away from the airports and will scan air movements occurring above ground in all directions. While terminal NEXRAD will supplement the enhanced Low-Level Windshear Alert System, LLWAS, and make up for some of its limitations, FAA views NEXRAD as a temporary system only to be installed at nineteen airports and to be replaced as soon as FAA's optimal system, the terminal Doppler weather radar, is ready.

The terminal Doppler is the system you have been discussing mostly today, and it is to be installed at one hundred airports. It currently is in research and development, and as Mr. McCarthy testified, it has a number of unresolved technical problems. The resolution of those problems will affect how effective it is when it's installed and how effective it becomes.

FAA and its researchers have stated that some of the radar's important performance objectives are going to be difficult to achieve, and FAA has testified that the procurement schedule is optimistic.

The terminal Doppler is intended to accurately forecast, detect, and measure wind shears; two, to have at least a ninety percent probability of detecting all microbursts and only a ten percent or less false alarm rate; and three, to be fully automated whereby radar signals are automatically translated by computers into information that the controllers and pilots can use.

FAA is sure that the radar can detect wind shears, but as Dr. McCarthy has confirmed, FAA is not sure that radars and computers together can forecast a microburst early enough to give controllers and pilots adequate warning and accurately measure the strength of the wind shear along the flight path; secondly, to meet the ninety percent, ten percent false alarm objective; or, third to deliver information in a form pilots and controllers can use as quickly as is needed.

FAA also must decide whether the radar can best perform its mission by being on or off the airport and whether its antenna should have a full circle or a more limited scan. The radar siting and scanning issues bear directly on the radar's ability to forecast wind shears, accurately detect their presence, and measure their severity or strength.

FAA's schedule calls for awarding a procurement contract for the hundred terminal Doppler weather radars in 1988. That is toward the end of next year. But it is not likely that all the research needed to determine whether FAA's objectives can be met will be completed by then. Since research on these problems is to continue this year and in 1988, FAA will likely have to decide whether to delay its procurement schedule or take a chance that what it buys will need further development after it's purchased in order to meet its performance objectives.

This is the decision that FAA is having to face in many of the NAS plan procurements, and it puts them in a difficult spot because they can be second-guessed either way they decide to go.

In addition to wind shear detection, FAA has another weather detection system in its plan that has not been discussed much today, and that is the new airport surveillance radar, called ASR-9. ASR-9 can distinguish among six levels of precipitation, five of which have been determined by FAA and the National Weather Service to contain phenomena strong enough to crash an aircraft. That is five out of the six.

Although the ASR-9 is a significant improvement over existing airport surveillance radars, FAA has not yet developed guidance for how controllers are to monitor and report the additional weather information to pilots. Based on our reviews of controller workload and methods for disseminating weather information, we think it's probable that some of the weather information that is available from the ASR-9 will never be received by pilots because controllers are often too busy directing air traffic to give weather information.

FAA plans to provide ASR-9 precipitation intensity information on air traffic controllers' radar displays so that they can watch it almost continuously. But individual controllers will be responsible for deciding which pertinent information to provide to pilots. Only two of the six precipitation intensity levels can be displayed on the controller's radar screen at any one time, and to view all five of the hazardous-weather levels, controllers will have to adjust their display three separate times, will have to turn the channel. We believe there will be times when controllers' workload will not allow them to monitor the radar display in this manner or to provide the information to the pilots.

This whole question of communication between the controller and the pilot and the detection equipment is an important one. FAA knows that it needs to provide more timely weather information to pilots to improve air traffic control system safety. For example, in February 1984 the Air Line Pilots Association notified FAA that its highest weather priority was for real-time information on wind shear, thunderstorms, and runway conditions at airports. FAA has included the Mode S data link in the NAS plan to send weather information directly from ground-based weather detection systems to inflight aircraft equipped to receive it, without involving the air traffic controllers.

FAA's intention is to relieve busy controllers of much of their weather dissemination responsibilities, thereby enhancing productivity and safety. It is unlikely, however, that the controller's role in hazardous-weather dissemination will be lessened in the near future. First, FAA's NAS plan does not now include uplinking wind shear and thunderstorm-related data. Instead, FAA proposes to use Mode S to send mostly routine information that is already available to commercial aircraft over a private data link service and that general aviation pilots concurrently access from FAA.

We understand FAA is sponsoring research and development which might allow wind shear data to be directly conveyed to pilots some time in the future, but FAA has not yet made this part of the NAS plan.

Secondly, few general aviation pilots, the group FAA believes will benefit the most, are expected to install the Mode S avionics necessary to receive weather information over the data link before the end of this century. To receive hazardous-weather information over Mode S, an aircraft will have to be equipped with an avionics package including a Mode S transponder, a computer, and a printer or a display.

Although FAA has recently mandated that any transponder installed after January 1, 1992, must be Mode S, aircraft presently equipped with today's predominant transponder that is not capable of receiving Mode S data are not required to reequip, and FAA expects many aircraft to continue using the existing transponder rather than installing Mode S.

A November 1986 FAA study estimated that only eighteen percent of all aircraft will have a Mode S transponder by 1995. While the study did not estimate how many of the aircraft will have the additional computer and printer or display necessary to request and receive Mode S weather messages, FAA recognizes that the number of aircraft capable of receiving data link information is likely to be less than the eighteen percent having a Mode S transponder in 1995. Consequently, controllers will continue to be the primary source of hazardous-weather information for most pilots.

Just to summarize for a minute, it will take FAA several more years to achieve its objectives of more accurate hazardous-weather detection and more timely communication of weather warnings to pilots. A number of unresolved technical issues about the performance of terminal Doppler weather radar are unlikely to be resolved before FAA's planned procurement of the system in 1988. This could result in procurement delay, continued development following procurement, or reductions in the radar's planned capabilities.

ASR-9 thunderstorm-related detection capabilities will depend on already-busy controllers to monitor and report weather problems to pilots, an additional duty they may not always be able to perform, and present FAA plans do not call for the Mode S data link to automatically communicate radar-detected wind shear or thunderstorm-related information from airports to pilots. Until such a system is developed, pilots will have to continue to rely on controllers for this information.

That concludes our prepared testimony, Mr. Chairman. We will be happy to answer any questions.

Mr. OBERSTAR. Thank you very, very much for that thorough review and, as I said at the outset, for the preparation in advance of the hearing that resulted in much of the testimony we have already received and the documentation that is already on the record.

I think you put your finger on the heart of the issue that we are dealing with here as far as the FAA role is concerned; that is, the two-pronged dilemma: the FAA being subject on the one hand to criticism that it isn't moving fast enough, that it is delaying procurement of a very important weather detection system that could be of incalculable value to aviation, but on the other hand, subject to criticism for not having sufficiently tested the system that it is planning to put into place so that we know it will work, that it will be adaptable to any future improvements in technology, weather and data storage or data retrieval or real-time logic.

This is something that I think we need to focus on here. Is there a valid basis for the FAA representation to the Appropriations Committee, the Transportation Appropriations Subcommittee, I should say, that it is unable to use some $130 million that the committee is preparing to provide in fiscal year 1988 for initial procurement of the terminal Doppler weather radar system?

Mr. McLure. That is something that I personally can't answer. I don't know if Art or Virgil have done any work to validate that. I do know that that is what the Appropriations committee staff told us happened, that FAA said they wouldn't be able to use it. That's why they took it out.

They did leave $10 million available to start the procurement if FAA found that it was ready.

Can either of you respond?

Mr. Schroeder. I think it was the fact that FAA says they didn't plan to do the procurement until late fiscal year 1988 anyway, and that their schedule is optimistic, but they left them in the $10 million in case they were ready in 1988 but that they would go ahead and give them full funding if they would be ready in 1989.

Mr. Oberstar. Well, what is your assessment of the status of the FAA? Are they now ready to begin? Are they being overly cautious? What is your objective assessment?

Mr. Schroeder. Well, I think, as we heard today, there are some unresolved technical issues that remain to be done, you know, whether we can forecast the impending microburst by detecting the precursors. At present we do not have that type of an algorithm. We are going to do research in 1987 and 1988 to try to resolve several of these technical problems. By FAA's own statement and testimony that this is an optimistic schedule, I think that has driven the reduction in the funding for this particular year.

Mr. McLure. On the other hand, Dr. McCarthy is a very convincing researcher. He really believes he is going to be able to answer these problems and develop the system. I think FAA is in a spot that they have to go as far as they possibly can as quickly as they can, and probably they feel—and I probably would feel the same if I were in their position—that they have to take as many chances as they can with this procurement without, you know, really taking a serious risk of having the whole thing not work.

So I think they will probably go right up to the threshold and then if there is reasonable assurance that most of it is going to work, then they will probably go ahead and buy. And that is probably what I would do as well.

Mr. Oberstar. You made reference to the Mode S system. Is that the problem? Is Mode S the heart of the problem, that it is not versatile enough to accommodate the other technology being developed?

Mr. McLure. Art knows more about Mode S than I do. Mode S is going to be a problem in connection with a lot of the NAS plan, because it is the primary source of information for the pilots and the pilots are going to depend on it considerably.

Mr. Shantz. Mode S relies on processors. One is called a weather communications processor and one is called a center weather processor. They are two different processors. The communications segment of the Mode S data link requires the weather communications process or to process raw data, such as a radar signal algorithm that says there is a microburst here. That data has to be processed.

There has to be a data base. The data then have to be transmitted on data link. The pilot has to request a message, "Do we have a wind shear warning in effect? Is there a wind shear warning? I am approaching O'Hare. What's going on?"

He queries the system. The system tells him the present status. It's possible that data link could contain some sort of a written message such as, "Wind shear warnings in effect." Captain Sifford mentioned, "Runway 36 left." That would be nice if everything was that neat.

As the system is presently designed, it does not, however, have space or capacity to transmit radar messages, that is, the radar signal itself. So the cockpit radar display cannot reflect what the radar on the ground sees. That is a big communications problem.

Mode S now, as FAA plans it in the level one design of the NAS plan, will not have wind shear data, will not have precip data. In the level one NAS plan, there is no weather—what we would call hazardous-weather data to be uplinked to the pilot. It is not there.

Mr. OBERSTAR. What type of information will it be sending to the pilot?

Mr. SHANTZ. Oh, they will be sending them things such as AWOS, ground-based sensors that tell you weather observations; that's temperature, humidity, wind direction and speed, cloud height. They will have some of the ATIS messages available on Mode S.

But they will not have the detection system data that we discussed here today; that is, either the terminal Doppler or terminal NEXRAD or ASR-9 weather channel data.

Mr. OBERSTAR. Is it a waste of money to invest in Mode S?

Mr. SHANTZ. Is Mode S a waste of money?

Mr. OBERSTAR. Yes. [Laughter.]

Mr. SHANTZ. It would be imprudent of me to hazard a guess on that. It doesn't appear to be a very timely——

Mr. OBERSTAR. Perhaps you can find some more diplomatic term to describe it, but are we not making the right investment of money? Would it be better spent someplace else?

Mr. SHANTZ. Mode S data link does not appear to be a very timely medium for communicating aviation weather hazards.

Mr. MCLURE. But the data link itself is to be used for a number of other things, and there is no question that the NAS plan needs a data link. So whether Mode S is a waste of money, I would say not. They need a Mode S, they need a data link. Whether Mode S, as designed, will do everything that it needs to do, that's the big question, and right now I guess our answer would be there are things it would be nice for it to be able to do that it presently is not planned to do.

Mr. SHANTZ. Ideally, FAA would manage and transmit weather, types of weather data and messages in three packages in their Mode S data link. The first package, which is the one that we allude to in our testimony when we say, "The information is already available", it is already provided by flight service stations. It is already provided commercial flights on the ACARS system. That first package of information is to be available roughly in the 1990 time frame.

A subsequent package of information which might include the types of hazardous weather we are talking about would not appear until probably 1997.

Now, you are talking about a Mode S system that is incompatible with a satellite-based system. You are talking about a time frame that is close to the turn of the century when it is going to be implemented. And as for the utility of the system, there are sufficient questions to wonder about that.

Mr. OBERSTAR. In previous hearings GAO has raised questions about the technical feasibility of TDWR systems, and specifically talked about the rate of update of information, ground clutter problems, data relay. How far along is the technology, in your judgment, keeping in mind the testimony of Dr. McCarthy earlier today who gave a 1993 time frame for TDWR?

Mr. SHANTZ. We would have no basis for disputing or questioning any of the time frames that Dr. McCarthy suggested. Whether or not things can be accomplished that have not yet been accomplished in two years or four years or six years, we really have no basis for saying. That is looking forward.

Looking backwards, we can find a number of instances where time frames have been optimistic. The NEXRAD program is one where I think people are familiar, or more familiar, in that the time frames for that particular project have gone on considerably beyond what they were initially estimated to be, not to say it isn't a worthwhile project, just to say that things are frequently more difficult than they seem.

Mr. McLURE. Yes. I think our warnings last year were of the same type. Again, it was a situation where FAA was on the verge of buying something that it hadn't yet proven, and that is still essentially the same situation.

Mr. OBERSTAR. Looking at the problem of the technology, this is not like buying an automobile.

Mr. McLURE. Right.

Mr. OBERSTAR. It's not like buying a telephone system where you go in and essentially get it off the shelf. This is a great deal more complicated than most other purchases or acquisitions one is going to make, even in this advanced technological society. What is the lead time necessary—if you want tc have this terminal radar system in place—what is the lead time necessary to do so?

Mr. SHANTZ. The terminal Doppler weather radar schedule that FAA offers right now is late 1992, early 1993.

Mr. OBERSTAR. Is that for putting it in place, having it operational?

Mr. SHANTZ. That is to have a system installed. To assume that it is commissioned as operational and ready to go, I think a meaningful date would have to be within that time frame unless——

Mr. OBERSTAR. Does that mean installed at the planned one hundred airports?

Mr. SHANTZ. No.

Mr. **Schroeder**. No. The first operational date for the terminal Doppler weather radar is September 2, 1992. That is the first of the hundred. The last operational date for their schedule is May 24, 1995, with the letting of the procurement contract in late fiscal year 1988.

Mr. **Oberstar**. So that is a—is that, in your judgment—have you analyzed the technology, the information, the representations made by FAA sufficiently to say, "That's reasonable; they're doing this in the right time frame," or, "They need more time," or, "They can do it sooner"?

Mr. **Schroeder**. I think we have some feeling that it may be very difficult to get all the technical issues resolved by the procurement date, but we have no feeling that this is an unreasonable schedule otherwise if they could get the procurement underway at that time. We have no basis for saying that that's unreasonable.

Mr. **Oberstar**. Is one hundred the number of TDWR the FAA plans to acquire? Is that roughly correct?

Mr. **Schroeder**. Yes.

Mr. **Oberstar**. One hundred first level airports.

Mr. **Schroeder**. It's actually one hundred two. One hundred of them will go to airports, one will go to the FAA Technical Center in New Jersey, one will go to the academy in Oklahoma City.

Mr. **Shantz**. I might add on that point, Mr. Chairman, the draft analysis of the terminal Doppler weather program by Martin Marietta, which is responsible for the technical direction of the project, indicates that those dates are very optimistic, that cost and schedule risk create about a thirty-five percent chance that the project will be completed within those dates and for the cost estimated.

Mr. **Oberstar**. Only a thirty-five percent chance?

Mr. **Shantz**. That's correct.

Mr. **Oberstar**. How did the FAA arrive at the number of TDWR's to acquire?

Mr. **Schroeder**. I think it tried to cover most of the airport traffic. I know the nineteen airports that will be covered with the terminal NEXRAD radar is estimated to cover about sixty percent of the traffic. And I am not just sure what the percentage of traffic will be covered by the one hundred, but I think it would get up relatively high.

Mr. **Shantz**. Over ninety, over ninety percent coverage. I think the objective, sir, in establishing an airport number is to have the overwhelming proportion of enplanements covered by these radars, and I believe with one hundred airports coverage is approximately ninety-three percent or ninety-four percent of all the passenger traffic. With roughly thirty radars or thirty-five radars, I think you'd cover about two-thirds of the enplanements or seventy percent of them.

Mr. **Oberstar**. So they used a yardstick of passenger traffic?

Mr. **Shantz**. Passenger traffic and weather occurrences, thunderstorms.

Mr. **Oberstar**. Was data from the LLWAS system used to identify the potential sites at which FAA will locate the systems?

Mr. **Shantz**. No, it was not.

Mr. **Oberstar**. What was used?

Mr. Shantz. A study was done by Fujita at the University of Chicago, indicating that thunderstorms were very pervasive and, based on these data, which showed the prevalence of thunderstorms throughout the country, a determination was made that a large number of airports would have to be covered. Martin Marietta then did a justification, preliminary justification, for the number of systems that would be required, and the two principal variables were thunderstorm occurrence and the number of enplanements.

Mr. Oberstar. So there was some factor given to severity of weather conditions?

Mr. Shantz. Yes.

Mr. Oberstar. At various airports. But it was done by the Fujita study that you referenced earlier?

Mr. Shantz. Yes.

Mr. Oberstar. Under contract to FAA?

Mr. Shantz. Yes. Weather occurrence and enplanements were the two principal criteria that were used.

Mr. Oberstar. I have some other questions, but I would like to yield at this time to my colleague from Pennsylvania.

Mr. Clinger. Thank you, Mr. Chairman. I just have one or two brief questions.

GAO has done a number of surveys and studies with regard to air traffic controllers on various issues affecting air traffic controllers, including attitudes, work performances, working conditions, and other factors, over the years. I wonder if you have ever, in the course of those examinations or surveys, asked the question about how they would feel about their role as weather communicators? That is, have you ever surveyed them to see whether they viewed their role positively as somebody who should be communicating weather data to pilots or if they considered that an imposition because their primary role was safety and that was extraneous to their primary role?

Mr. McLure. We never asked that question exactly. The controllers, I think, view weather as a safety-related item and view that as an important function. What they told us two years ago, nineteen percent of them said that they frequently had to refuse to give weather information because they were too busy with their primary duty, which is aircraft separation. And if you added people who said they did it occasionally, it came up to 53 percent who said that they either occasionally or frequently had to refuse to provide weather information when it was requested.

The other work we've done involves measuring how the controllers acquired and then repeated weather information to the pilots. That was a very laborious process that involved handing a piece of paper from one controller to another, and it took a long time, which is another reason that we are concerned that a better method of relaying weather information to pilots be considered by FAA.

Mr. Clinger. In other words, whatever the system, it should be one that is consistent and there one hundred percent of the time.

Mr. McLure. Yes.

Mr. Clinger. Not sort of dependent on whether the controller had the time to relay the information or not and other factors that would make it less than reliable.

Mr. McLure. Right. Now, that's not to say that FAA doesn't realize that. That is one of the reasons they put the ASR-9 data on the screen, so the controller would have it conveniently. But it's still going to be another duty that a busy controller may not have time to do.

Mr. Clinger. Just one other item. I am not sure I quite understand what the procedure is going to be with regard to the nineteen NEXRAD units which are going to be configured as Doppler units and installed in nineteen airports until a Doppler unit can be installed, after which it will be reconfigured as a NEXRAD and redeployed where it was originally supposed to be. Is that the scenario?

Mr. McLure. That's right.

Mr. Clinger. That's a little confusing.

Mr. McLure. It is confusing. But I think it's a good example of some real flexibility on FAA's part in recognizing the need for better weather information and doing something about it quickly. It's even more confusing than you related. They actually had sixteen units, NEXRAD units, which are primarily units that look up and are for use in the en route environment, and they were going to use those in the Caribbean and other places around the system. They decided that they needed Doppler information at key airports early, and so instead of deploying those in the en route system, they took the first sixteen and put them where they could use them around airports, which I think was a good idea.

Mr. Shantz. Just to elaborate on that for a moment, our testimony refers to two weaknesses in the enhanced LLWAS, that it cannot detect microbursts occurring beyond the boundaries of the airport and above the ground level—that is, several hundred feet above the ground. And terminal NEXRAD would address both those weaknesses. It can see them in the air, look up, and it can look out beyond the boundaries of the airfield itself. So in that sense it is a reasonable interim approach to trying to address hazards.

Mr. Clinger. And a step forward from what was available through LLWAS?

Mr. Shantz. Indeed.

Mr. Clinger. Thank you.

That is really all I have, Mr. Chairman. Thank you.

Mr. Oberstar. Thank you.

How does terminal NEXRAD differ technologically from TDWR?

Mr. Schroeder. One of the primary differences is the band that it will—the radar band the signal will operate on. The S-band frequency of most major airports is currently full, and FAA had to get a special waiver, five-year waiver, to install the terminal NEXRAD radars at these nineteen airports. So the terminal Doppler that has been decided will work on a C-band, which has more capacity. That is one of the major differences FAA has stated.

There are other differences. For example, the antenna is of a large size. It rotates a full three hundred sixty degrees. Now, that limits the number of scans you can make in a one-minute time frame to update your information and get it to the pilot. Like you may be able to make two or three scans of the airport in one minute and update your information. With the terminal Doppler weather radar, it's likely that it will have a smaller antenna; that has not been decided for sure yet. And it could do a sector scan, and maybe even a combination sector and full-circle scan and you could get eight or nine scans of your runways within that same one minute which would give you more data and possibly more accurate detection. So there are some differing capabilities there.

Mr. **Oberstar**. Well, what is the cost of the NEXRAD system?

Mr. **Shantz**. $103 million.

Mr. **Oberstar**. And FAA is moving ahead with NEXRAD.

Mr. **Shantz**. That's correct.

Mr. **Oberstar**. Is it a platform? Is it something that you can build on and add to it either the software or the hardware of the terminal Doppler, or do we develop a whole new system and, like the hand-me-down, give the NEXRAD to the poor cousins?

Mr. **Shantz**. I don't know about the poor cousins.

Mr. **Oberstar**. That's us up there in northern Minnesota, up in the boondocks. [Laughter.]

Mr. **Shantz**. I see. The software, for example, the work that NCAR is doing on software, that software work and those displays and systems would be applicable to the terminal NEXRAD or the terminal Doppler. There are some requirements that there be a certain commonality of hardware. I think there is an eighty percent requirement that terminal Doppler and terminal NEXRAD have common hardware.

Software detection algorithms shouldn't vary as between bandwidth. They would vary in terms of scanning strategy, whether you're doing a three-sixty or a sector scan, and that would be a function of the kind of antenna and bandwidth.

So, detection software should be or is supposed to be applicable to either. Hardware is supposed to be quite interchangeable, at least eighty percent so. That is the objective.

Mr. **Oberstar**. Is the view then of the FAA—say, to put the best light on it—that NEXRAD is an insurance policy in between now and terminal Doppler and that they are trying to do the best thing that they can for aviation safety in weather matters and that they are moving ahead with something that is known and developed and is state-of-the-art and will move ahead with this pending onstream of the best or the ideal system? Is that it?

Mr. **McLure**. Yes. That is just the way I would see it.

Mr. **Oberstar**. Is that what you have detected in their thought process?

Mr. **McLure**. Yes.

Mr. **Oberstar**. Going back to the testimony we received earlier in the day, what is the significance of accurately measuring headwind and tailwind in this context of developing the best weather detection system possible? I think your testimony at page 3 refers to—well, let me just quote: "FAA is not sure the radars and computers together can forecast a microburst early enough to give controllers and pilots an adequate warning and accurately measure the headwind and tailwind along the flight path."

What is the significance there, in your judgment?

Mr. **Shantz**. Well, you have heard testimony today that the aircraft approach twenty to thirty to thirty-five percent over their stall speed. And there is some margin, in other words.

What the pilot wants, the type of information pilots have indicated to FAA that they want, is the windspeed of the air, what are the effects of the microburst on me, along my route of flight; what kinds of headwinds and tailwinds am I going to have? If they know that, because that's where they live, that's where they work, they can readily compute the effects on their aircraft and the measures they have to take. That is, they feel, the most important item of information they want.

You have also heard testimony that some wind shears or microbursts are asymmetrical or irregular in their shape, which means that on one side there is a great deal more force than on the other. Unless the radar is looking right down the flight path, it will not be able to provide the pilot with his headwind and his tailwind components. He won't know, first, the initial increase in airspeed, and he won't know the subsequent decrease in airspeed. That's important information.

Conversely, we have heard Dr. McCarthy talk about precursors and their importance in forecasting or anticipating these phenomena.

Mr. Oberstar. Yes. Very, very significant.

Mr. Shantz. And to do that, the radar cannot simply be looking down the flight path, it has to be looking up in the air. And if it's on the airport, it's virtually impossible to look up in the air. It has to be away from the airport.

So it's possible that you have competing objectives; that is, the importance of the precursors and the importance of the headwind or the airspeed effects on the plane. How you go about doing both is a very difficult question, and it's something that has to be decided before you make siting decisions as to where you're going to locate the radar, on or off the airport, and what type of scanning strategy and so forth.

They all come together in a series of very complicated decisions, and the unknowns right now for those decisions are quite considerable. I believe FAA would be very hard-pressed if asked which they wanted to trade off: headwind or precursors. They would like both.

Mr. Oberstar. Parenthetically, I find it ironic that we are discussing very high technological matters involving detection of complicated weather systems and we can't get a microphone system that works without static here on Earth. [Laughter.]

Why can't you put up the graphics? Why can't we have a system that puts up into the pilot's reach a system that shows what is happening so that you have a ground-based detection system that uplinks the information, puts it in the cockpit for the pilot to see? As our previous witness testified, he needs that information right now. Two minutes, two minutes is maybe two to four aircraft, depending on how quickly they're bringing them in. We haven't got that much time. There isn't a big cushion.

Mr. McLure. I don't know if your question is rhetorical. But I think that FAA's answer would be that they can. The question is when, how long is it going to take, how much is it going to cost? And I think our answer is that we think they probably can someday, too, but they're not going to be able to for a while. And right now, it's not even really officially in their plan.

Mr. **Shantz.** Another short answer might be that for the raw data they don't have the right medium. Data link is not the right medium for raw radar data. It cannot accommodate it.

Mr. **Oberstar.** Well, given the five objectives to be achieved, terminal NEXRAD will see a microburst, as I understand it, but it won't put the information on a screen. Now, aviation will have to wait several years for that. Is that a fair assessment?

Mr. **Schroeder.** Well, it will be automated, just like the terminal Doppler weather radar. Neither system will have a meteorologist, so you automatically have to detect, interpret the system with an algorithm, and automatically give those warnings to the controller, who then will pass it on to the pilot.

Mr. **Shantz.** I think it's the nature of the controller warning which you are alluding to, it's possible that the initial display for the controller might not be on a screen or might not be on a controller display, but rather in a separate display of some sort. Subsequently, if they refine their science and their algorithms and the display technology, they might be able to put the whole thing on a scope.

Mr. **Oberstar.** That is what I was leading up to, was the workload that is on the controller. And we will have to suspend there for this vote and return as quickly as possible.

[Recess.]

Mr. **Oberstar.** The subcommittee will resume its sitting.

Mr. McLure, to revisit a question asked earlier in another way, does the GAO concur in the decision of FAA to defer initiating acquisition of the terminal Doppler weather radar system for at least another year?

Mr. **McLure.** Well, to review what they know and what they don't know and what they want, they want the radar to forecast, to see and to forecast microbursts, to be ninety percent reliable, and to be fully automated.

Now, what do they actually know at the present time? They know the radar can see the microburst. They know that because when meteorologists watch it, they can identify the microburst. What they still have to do, though, is to get a computer to be able to do that and to translate what it sees into an understandable signal for the pilots and controllers that is unambiguous and easy for them to interpret.

The systems they have are logical steps towards that, and they are doing the research they need to do to get terminal Doppler to work. We think they should buy it as soon as they have reasonable assurance that it will work or that they will achieve at least a large part of what they want to make it worth the money that they are going to spend on it.

I think that given the FAA has even said that their schedule of finishing the procurement or finalizing the procurement in late 1988 was optimistic, I think it's reasonable to assume that they can buy it sometime in 1989 without really losing anything, especially considering that the research contracts themselves run through 1988. So they already know they are going to be continuing this research at least that long.

Mr. **Oberstar**. I think that is a fair assessment. If indeed the research is continuing, you don't necessarily move ahead with the acquisition.

GAO has testified several times before this subcommittee and before other committees, expressing its concerns about the workload of the controllers. The current state of the art of weather detection and dissemination depends heavily on the controller as the link. What concerns does GAO have about the controller workload, about adding another element, another increment of important activity for the tower controller or controllers in general? Do you see any problems, given the shortage of controllers and the growing workload upon controllers, in adding this further element of providing weather information in timely fashion and in the detail needed for pilots to be able to respond?

Mr. **McLure**. The controllers have a priority list of duties, and so when they are busy separating traffic, they understand that that is their first priority, and if they are asked for weather information and don't have time to provide it and still separate traffic, then they simply refuse to give the weather information. So that it doesn't add to their workload in the sense that they can refuse to provide it. What concerns us is that there is weather information, hazardous-weather information, that pilots need and can use that won't be available to them in the times when the controllers are busy.

Now, the controllers are most likely to be concerned also because they will have data that they know pilots want, and of course none of us in our professional capacity wants to refuse to provide the services that we are being paid to provide. So it will concern them to refuse to give the information out, and that will add, I think, to their general sense of anxiety in their work. Nevertheless, I think that they can carry out the priority list of duties that they have without any trouble.

It is simply that there will be information in the system that pilots could use if it was available to them, but it won't be available to them through the means that FAA has to use.

Mr. **Oberstar**. A final question. What are the specific objectives of terminal Doppler weather radar, and which of these objectives are achievable in the time frame envisioned by the FAA, and what are the unknowns, what are the performance capabilities that we don't yet—or the technology has not yet—been able to pinpoint?

Mr. **McLure**. Yes. Simply stated, of the objectives FAA has, they know the Doppler radar can see microbursts; they want it to be able to interpret what it sees automatically. They don't know if they will be able to get it to do that yet. They think they will. They would like the information to be available to controllers and pilots in an unambiguous way. They think they will be able to do that, but they don't know it yet. They would like the radar to be able to tell the pilots what they will be encountering and exactly when and where. That is all part of this unambiguous message that they are not yet sure they will be able to do.

Another problem is that because of the various kinds of microbursts there are, they are not certain that they will be able to measure the exact forces that pilots will encounter. As Dr. McCarthy said today, they think they will be able to, and they think they will be able to do it with a certain amount of variance from the actual, but they don't know that yet. And those are the things that they are conducting research on right now that Dr. McCarthy said would be a couple of years before they know the answers to.

Mr. OBERSTAR. Thank you very much.

Mr. Molinari.

Mr. MOLINARI. Just one question. I don't know whether this was covered in my absence, but the Chairman raised a good point on the issue of controllers and giving weather information. This takes us back to a study which GAO did a couple of years ago which was a very comprehensive work and gave a lot of useful information to all of us: what the attitudes of the controllers were, what their limitations were, where there were deficiencies, et cetera.

But the one thing that stuck out with respect to the subject that we're discussing today was the fact that a very large percentage, as I recall, of controllers were refusing to provide weather information because they were not able to provide it, as you put it, at the time that it was really needed most. As I recall, also, one of the reasons was the shortage of controllers at many areas.

Do you have any way of giving us an update on the status of that today within the system? Have there been any changes that you know of? Is the percentage of controllers that are furnishing weather data to pilots, when needed, on the increase?

Mr. MCLURE. No. We don't have any later data than we had. We rely on that data we gathered, a couple of years ago so much, I am getting the feeling that we ought to do something about getting new data. FAA has done a lot in the last couple of years, they say, to better manage the traffic the controllers are confronted with. And of course, the controllers are becoming better trained all the time as they gather experience. So my feeling is that the situation probably has changed some in the last two years, but I don't know if they would answer the question differently or if they are refusing either more frequently or less frequently the weather information than they used to. I guess we just don't know.

Mr. MOLINARI. Fine. I tell you what I would like to do. I would like to sit down with you and maybe request an update on that report because I think that was extremely important information. I think we would like to get a new look at the system. I think the time would be appropriate.

Mr. SHANTZ. I think what we had then was about twenty percent, nineteen percent, of the controllers said during peak hours they often or very often do not provide weather information when pilots request it, and another thirty-four percent or so said occasionally or sometimes they didn't do that.

What we point out in this testimony is that controllers are being provided more information than they were formerly, that a program designed to get controllers out of the loop is in fact giving controllers more information than they ever had before and at least at the present time is forcing them to decide in the case of the ASR-9 weather channel what information is pertinent, which channel do I look at and how much time do I have, how much can I provide this guy? That is a lot of responsibility on a guy you're trying to take out of the loop.

Mr. MOLINARI. I appreciate that very much. Thank you very much.

Thank you, Mr. Chairman.

Mr. OBERSTAR. Again, thank you very, very much for your splendid presentation and for the immense assistance you have been to the subcommittee, not only at this hearing but also at the other hearings that we have had relating to safety in general and specifically to the role of safety in aviation.

Mr. McLURE. You're welcome. We are happy to work with you.

Mr. OBERSTAR. Thank you.

[The prepared statement of Mr. McLure follows:]

United States General Accounting Office

GAO Testimony

For Release
On Delivery
Expected at
9:30 a.m. EST
Tuesday
June 30, 1987

Hazardous Weather Detection and Warning Systems

Statement of
Herbert R. McLure, Associate Director
Resources, Community, and Economic Development Division

Before the
Subcommittee on Investigations and Oversight
House Committee on Public Works and Transportation

Mr. Chairman and Members of the Subcommittee:

We are happy to be here to comment on the Federal Aviation Administration's (FAA's) development of wind shear and hazardous weather detection and warning systems for major airports. We are working in this area for the House Science, Space, and Technology Committee, and we are grateful to Chairman McCurdy and Members of the Transportation, Aviation and Materials Subcommittee for this opportunity to share our findings with you. My statement today will focus on some of the difficulties FAA faces in developing its new hazardous weather systems.

More than half of all fatal air carrier accidents are in some way attributable to weather. According to FAA, there are two main problems with its existing aviation weather system: Inadequate weather detection systems, and the lack of a quick way to communicate weather information to pilots.

To correct these problems, FAA's National Airspace System (NAS) plan calls for $1.5 billion worth of new weather systems. I would like to discuss FAA's plans in three areas:

-- wind shear detection,

-- precipitation and thunderstorm detection, and

-- communicating hazardous weather information to pilots.

WIND SHEAR DETECTION

Wind shear--an abrupt change in wind speed or direction--has been identified as a cause or factor in 18 accidents since 1970, which involved the loss of 575 lives. The need for more accurate wind shear detection and more timely weather warnings to pilots, particularly during the critical takeoff and landing phases of flight, continues to be a concern for aviation safety.

FAA is developing three new ground-based wind shear detection systems, but all three have either detection limitations or unresolved technical problems.

The first new wind shear detection system FAA plans to install is the enhanced low level wind shear alert system. The system will be installed at 110 airports by August 1992, and consists of 11 ground sensors placed primarily on the airport, twice the number of sensors the existing low level wind shear alert system has.

Although an improvement, FAA does not view the enhanced low level wind shear alert system as the optimal solution to the wind shear detection problem because the sensors for the most part still cannot detect wind shears that occur above ground level or outside the physical boundaries of the airport. This problem was illustrated by the 1985 Delta Airlines crash at Dallas/Ft. Worth International Airport where a microburst--the most dangerous form of wind shear--occurred away from the airport, beyond the low level wind shear alert system. This microburst did not come within the range of the sensors until some 10-12 minutes after it caused the crash.

The second wind shear detection system in FAA's plans is called the terminal NEXRAD radar. It will be capable of "seeing" wind shears and microbursts as much as 30 miles away from the airport. The radar will be located away from the airports and will scan air movements occurring above ground in all directions. While terminal NEXRAD will supplement the enhanced low level wind shear alert system and make up for some of its limitations, FAA views it as a temporary system, only to be installed at 19 airports, and to be replaced as soon as FAA's optimal system, the terminal Doppler weather radar, is ready.

FAA's third wind shear detection system, the terminal Doppler weather radar, is to be installed at 100 airports. It is currently in research and development and has a number of unresolved technical problems that could reduce its operational performance or delay its procurement schedule. FAA and its researchers have stated that some of the radar's important performance objectives will be difficult to achieve, and FAA has testified that its procurement schedule is optimistic.

The terminal Doppler weather radar is intended to: (1) accurately forecast, detect, and measure wind shears, (2) have at least a 90 percent probability of detecting all microbursts and only a 10 percent or less false alarm rate, and (3) be fully automated whereby radar signals are automatically translated by computers into information that can be used by controllers and pilots.

FAA is sure the radar can detect wind shears. But FAA is not sure the radars and computers together can (1) forecast a microburst early enough to give controllers and pilots adequate warning and accurately measure its strength along the flight path; (2) meet the 90 percent detection/10 percent false alarm objective; or (3) deliver information in a form pilots and controllers can use as quickly as it is needed. FAA also must decide whether the radar can best perform its mission by being on or off the airport, and whether its antenna should have a full circle or a more limited scan. The radar siting and scanning issues bear directly on the radar's ability to forecast wind shears, accurately detect their occurrence, and measure their severity or strength.

FAA's schedule calls for awarding a procurement contract for the 100 terminal Doppler weather radars in 1988, but it is not likely that all the research needed to determine whether FAA's objectives can be met will be completed by then. Since research on these problems is to continue this year and in 1988, FAA will likely once again have to decide whether to delay its procurement schedule or take a chance that what it buys will need further development after it is purchased in order to meet its performance objectives.

PRECIPITATION AND THUNDERSTORM DETECTION

In addition to wind shear detection, FAA has another weather detection system in its plans, a new airport surveillance radar, called ASR-9. ASR-9 can distinguish among six levels of precipitation, five of which have been determined by FAA and the National Weather Service to contain phenomena strong enough to crash an aircraft.

Although the ASR-9 is a significant improvement over existing airport surveillance radars, FAA has not yet developed guidance for how controllers are to monitor and report the additional weather information to pilots. On the basis of our reviews of controller work load and methods for disseminating weather information,[1] we think it is probable that some of the weather information available from the ASR-9 will never be received by pilots because controllers are often too busy directing traffic to give weather warnings.

According to Air Traffic Control, FAA's controller handbook (FAA 7110.65D), the controllers' first priority is separating aircraft. The handbook instructs controllers to issue "pertinent information" on observed weather, and to provide radar guidance around weather areas when requested to do so by pilots. FAA plans to provide ASR-9 precipitation intensity information on air traffic controllers' radar displays; individual controllers will be responsible for deciding which "pertinent information" on levels of precipitation intensity to report to pilots.

Only two of the six precipitation intensity levels can be displayed on the controller's radar screen at one time, and to view all five hazardous weather levels controllers will have to adjust their display three separate times. We believe there will be times when controllers' work load will not allow them time to monitor the radar displays in this manner or provide the information to pilots.

Even in those instances when controllers do have time, we believe there is a substantial risk that the complexity of the weather might result in important information being miscommunicated to pilots. For example, in a large, multi-celled storm, it will be difficult for controllers to explain to pilots the difference between potentially hazardous areas covered by weaker storm cells and certainly hazardous areas included in the strongest storm cells.

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[1] Aviation Weather Hazards: FAA System for Disseminating Severe Weather Warnings to Pilots (GAO/RCED-86-152BR, April 22, 1986) and Aviation Safety: Serious Problems Concerning the Air Traffic Control Work Force (GAO/RCED-86-121, March 6, 1986).

COMMUNICATION OF WEATHER WARNINGS TO PILOTS

FAA knows that it needs to provide more timely weather information to pilots to improve air traffic control system safety. For example, in February 1984, the Air Line Pilots Association notified FAA that its highest weather priority was for real-time information on wind shear, thunderstorms, and runway conditions at airports. FAA has included the Mode S Data Link in the NAS plan to send weather information to in-flight aircraft equipped to receive it, without involving air traffic controllers. FAA's intention is to relieve busy controllers of much of their weather dissemination responsibilities, thereby enhancing productivity and safety.

It is unlikely, however, that the controllers' role in hazardous weather dissemination will be lessened in the near future. First, FAA's NAS plan does not now include uplinking wind shear and thunderstorm-related data. Instead, FAA proposes to use Mode S to send mostly routine weather information that is already available to commercial aircraft over a private data link service and that general aviation pilots can currently access from FAA. We understand FAA is sponsoring research and development which might allow wind shear data to be directly conveyed to pilots some time in the future, but FAA has not made this a part of the NAS plan.

Second, few general aviation pilots, the group FAA believes will benefit most, are expected to install the Mode S avionics necessary to receive weather information over the data link before the end of the century. To receive hazardous weather information over Mode S, an aircraft will have to be equipped with an avionics package including a Mode S transponder, a computer, and a printer or display. Although FAA has recently mandated that any transponder installed after January 1, 1992, must be Mode S, aircraft presently equipped with today's predominant transponder, that is not capable of receiving Mode S data, are not required to reequip and FAA expects many aircraft to continue using the existing transponder rather than installing Mode S. A November 1986 FAA study estimated that only 18 percent of all aircraft will have a Mode S transponder by 1995. While the study did not estimate how many of the aircraft will have the additional computer and printer or display necessary to request and receive Mode S weather messages, FAA recognizes that the number of aircraft capable of receiving data link information is likely to be less than the 18 percent having a Mode S transponder in 1995. Consequently, controllers will continue to be the primary source of hazardous weather information for most pilots.

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In summary, it will take FAA several more years to achieve its objectives of more accurate hazardous weather detection and more timely communication of weather warnings to pilots. A number of unresolved technical issues about the performance of terminal Doppler weather radar are unlikely to be resolved before FAA's planned procurement of the system in 1988. This could result in procurement delay, continued development following procurement, or reductions in the radar's planned capabilities. ASR-9 thunderstorm related detection capabilities will depend on already busy controllers to monitor and report weather problems to pilots, an additional duty they may not always be able to perform. And present FAA plans do not call for the Mode S data link to automatically communicate radar detected wind shear or thunderstorm related information from airports to pilots. Until such a system is developed, controllers will continue to provide weather information to pilots.

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This concludes my testimony, Mr. Chairman. I will be happy to answer any questions you or other Subcommittee members may have at this time.

Mr. **Oberstar**. Our final panel today is Assistant Secretary for Policy and International affairs at the Department of Transportation, Matt Scocozza, accompanied by Mr. Neal Blake, Deputy Associate Administrator of Engineering for FAA.

Please rise and raise your right hands. Do you solemnly swear that the testimony that you will give before the subcommittee will be the truth, the whole truth, and nothing but the truth, so help you God?

Mr. **Scocozza**. I do.

Mr. **Blake**. I do.

Mr. **Oberstar**. Thank you.

TESTIMONY OF MATTHEW SCOCOZZA, ASSISTANT SECRETARY FOR POLICY AND INTERNATIONAL AFFAIRS, DEPARTMENT OF TRANSPORTATION, ACCOMPANIED BY NEAL BLAKE, DEPUTY ASSOCIATE ADMINISTRATOR FOR ENGINEERING, FEDERAL AVIATION ADMINISTRATION

Mr. **Scocozza**. Thank you, Mr. Chairman, Congressman Molinari.

Mr. **Oberstar**. Welcome, Mr. Secretary. We greatly appreciate having you before our subcommittee. I would note for the record that your testimony was volunteered by the Department, and we are very happy to have the testimony delivered at the Secretarial level and also that you have along with you the responsible FAA official who is at the working level. I assume that we will receive some very significant policy information and policy direction in light of the significance of your presence at the hearing today.

It is always a pleasure to have you at our hearings, and we appreciate the opportunity to work with you.

Mr. **Scocozza**. Thank you, Mr. Chairman. It is really a pleasure to be here this evening, and my presence does really underline our extreme interest in this particular project. There are several problems which I will point out in my testimony. I apologize, it is a little longer than five minutes, it's about eight minutes. But it covers all of the important areas. And I have a very long statement for submission in the record.

Mr. **Oberstar**. At this hour of the day, one need not apologize.

Mr. **Scocozza**. It's about eight minutes.

Mr. **Oberstar**. It is rather the subcommittee that extends its apology to all for the rather long day, punctuated by votes and other interruptions that we have had in the course of our hearing. But your testimony in full will be printed in the record, and we of course welcome whatever summary you wish to make, and also Mr. Blake.

Mr. **Scocozza**. Thank you. Without further ado, I will proceed.

I should note that the aviation system, including aircraft, airports, and air traffic control, has become so sophisticated over the years that flight in inclement weather is a routine occurrence. Such air travel happens every day with no derogation of safety.

Unfortunately, the aviation weather system is not without its problems. For example, the whole operation still tends to be more labor-intensive than the various agencies would like. Also, when serving as a middleman for conveying information to a pilot, the controller has to give first priority to separating traffic.

In short, notwithstanding the many achievements that we can all be proud of, projects that will produce more and better data, passing it along more quickly, and minimizing the air traffic control workload must continue. These are exactly the problems that FAA's weather projects are designed to address.

FAA, in cooperation with other agencies and the aviation industry, has made significant progress in addressing these issues in recent years. My written statement discusses several of the most substantial accomplishments.

However, describing a few of the things that have already been done tells only a small part of the story. The Department of Transportation's and FAA's commitment to carrying out the National Airspace System plan is, among other things, a commitment to weatherproofing the airways by the year 2000.

Specifically, we are working together with the National Weather Service and the Department of Defense on the next generation of weather radar, known as NEXRAD. It is a new technology Doppler radar that will replace the current network of weather radar systems, providing a national network of weather radars. The program is now in the prototype phase, with Raytheon and UNISYS competing for a production award.

Tests will be completed shortly and the contract award for limited production of ten systems will take place next month. If they prove satisfactory, a decision to produce the full one hundred sixty-five units is expected in July 1988. System deliveries will begin in September 1989 and end in May 1994.

Although NEXRAD is basically an en route weather radar, DOT is committed to providing improved weather radar for terminals as soon as possible. This decision reflects the widely-shared concern about wind shear, a sudden change in windspeed or direction, which has been implicated in the crashes of a Pan Am 727 flight in Kenner, Louisiana in 1982, and of Delta Flight 191 in August 1985 at Dallas-Fort Worth. Consequently, the first seventeen NEXRAD systems received by the FAA will be reconfigured with software appropriate to airport terminal areas for wind shear detection and installed as Terminal NEXRADs at the most vulnerable airport locations.

The Terminal NEXRAD is basically an interim system to provide wind shear detection at major airports until the Terminal Doppler Weather Radar System, or TDWR, is ready. Like Terminal NEXRAD, TDWR will warn controllers and pilots of hazardous weather conditions near the airport, particularly microbursts with attendant wind shear conditions and gust fronts.

Serious consideration is being given to placing TDWR's at as many as one hundred terminals around the country. In late 1988 FAA plans to award a contract for TDWR's, with the first installation slated for 1992.

Let me emphasize at this point that to the extent there have been some delays in NEXRAD, Terminal NEXRAD, and TDWR, those delays have resulted primarily from technical obstacles, mostly in the software development areas. What problems there were have not been caused by budgetary constraints.

TDWR is presently facing a budgetary obstacle, however. Our request for $130 million in fiscal year 1988 has been reduced in the House Appropriations Subcommittee markup to the $10 million level. This amount is not adequate for a critically-important safety project that should not be subject to unnecessary delay. Without approval of our original request for terminal Dopplers, we will not be able to award a contract in fiscal year 1988, as is currently planned. Secretary Dole is extremely concerned about this program cut.

The terminal Doppler program which can detect wind shears at farther distances and higher altitudes will be complementary to the Low-Level Windshear Alert Systems, or LLWAS, which were initiated in 1975. That system has been installed at ninety-nine airports, with coverage planned for eleven additional airports by the end of 1987.

LLWAS systems will also be enhanced with additional sensors and better processing and display capabilities. An operational test and evaluation of the enhancements is underway this summer in Denver. Completion of the enhanced LLWAS program is scheduled for the end of 1990.

Windshear, particularly that stemming from microburst, is such a serious threat that relying on ground-based sensors is not sufficient. FAA has been pursuing a combination of strategies—ground-based sensors, pilot training, and airborne alert and guidance equipment. On June 1 the FAA proposed a regulation to require large jet airliners to have equipment that will tell pilots when they have encountered a wind shear and how to escape it.

In addition, the proposal would require airline flight crews to receive ground school and simulator training in wind shear recognition and recovery procedures. FAA has provided a training program, developed by the Boeing Company and others, to six hundred airlines and related groups.

Also with regard to airborne equipment, FAA and NASA are developing the system requirements for forward-looking wind shear sensors. With these sensors on board, the flight crew would be able to reject a landing or takeoff before the aircraft entered the hazardous area. This program also includes the improvement of existing detection systems, improvements that can be made in flight guidance for pilots during wind shear recovery attempts, and the continuing characterization of the wind shear hazard.

Another system, the Automated Weather Observing System, or AWOS, is a ground-based device with multiple sensors for reporting surface observations of weather parameters. FAA's contract for two hundred six such systems for use on non-towered airports has been terminated due to contractor performance problems. We have decided, instead, to proceed with procurement of around one hundred sixty commercially available AWOS units.

We have also prepared a memorandum of understanding with the National Weather Service for a joint AWOS procurement. FAA will provide all capital and operations funds for over five hundred AWOS units for both towered and non-towered locations, while National Weather Service will be responsible for buying, installing, operating, and maintaining that equipment. We are optimistic that this arrangement will produce quality weather information and fully meet the needs of the aviation community.

The Central Weather Processor, or CWP, is yet another NAS Plan undertaking. CWP is a computerized system for en route centers that will accept information from the NEXRAD radars and meteorological products from NWS, process what comes in, and distribute it to meteorologists and weather coordinators in center weather service units. The processed results generated by the meteorologist will be provided to the controller as an overlay on the air traffic control display and to the pilot via the Mode S data link. The Mode S data link program will enable us to transmit hazardous-weather information directly into the cockpit and thus eliminate the controller from this time-critical loop.

Counterpart avionics will be necessary for the airlines to benefit from the Mode S data link. The efficiencies seem promising, and the equipment also offers air traffic control options that did not exist before. The first Mode S system is scheduled to be operational in 1990.

I would be remiss if my testimony failed to mention FAA's automated flight service station program. Over three hundred flight service stations are being consolidated into sixty-one automated flight service stations with display and processing abilities that go far beyond that found in the old flight service stations. This is a critically important program and one on which we have consulted and cooperated with Congress on a continuing basis.

Several other weather forecasting and communications projects are summarized in my written statement.

Overall, we believe the FAA program is comprehensive and effective. It demonstrates a commitment to improved aviation safety and capacity well into the next century.

This concludes my remarks, Mr. Chairman. I would be pleased to answer any specific questions that you have, and certainly Mr. Blake is available to answer any detailed technical questions you or the other members of the subcommittee may have.

Mr. OBERSTAR. Thank you very much, Mr. Scocozza. I greatly appreciate your coming here with several very significant messages that are included in your testimony today, the first of which is that the FAA and the Department are prepared to move ahead with procurement in fiscal year 1988 of terminal Doppler weather radar, provided the money is made available, the information we have been focusing on this issue all throughout this day and have asked various witnesses about the readiness, the state of readiness of the technology and of the FAA to move ahead with it.

In between sessions this afternoon, during votes, I have sought out the two principal members of the Transportation Appropriations Subcommittee, Chairman Bill Lehman, and the ranking Republican, Mr. Coughlin, and discussed this matter with them. They told me that they had been notified by the FAA—I didn't ask whether they had been notified by the Department—that FAA is not prepared in fiscal year 1988 to let contracts on TDWR, and therefore the subcommittee downgraded the $130 million to the $10 million that is presently in the subcommittee bill for preparation to do so in fiscal year 1989.

Chairman Lehman indicated to me that tomorrow morning the full Appropriations Committee will be considering the subcommittee's action and that at that point the $130 million could be reinstated if the Department and the FAA are prepared to move ahead with procurement in fiscal year 1988, as you have just testified. And I think a letter ought to be dispatched from the Secretary tonight to Chairman Lehman and to Mr. Coughlin so that on a bipartisan basis the necessary action can be taken before we miss that opportunity.

I will communicate this to the Chairman. But I think it must come in writing from the Secretary if she is determined to move ahead at this point and feels that the time is now. Those monies can be reinstated tomorrow morning.

Mr. SCOCOZZA. If you will indulge me ten seconds, Mr. Chairman.

Mr. OBERSTAR. I see you are preparing to take that action.

[Pause.]

Mr. MOLINARI. Would the Chairman yield?

Mr. OBERSTAR. Yes.

Mr. MOLINARI. Mr. Scocozza, you volunteered to come here today, which is a welcome development for us. Would one of the reasons why you asked to come or your Department asked for you to be here today be to seek assistance for the funding levels that we are discussing now?

Mr. SCOCOZZA. If that is some of the outcome of my presentation, Congressman, I think my presence will have been well served. But it is once again to emphasize our commitment to this program. The NAS plan, as you are well aware, is about a $12 billion program. The Doppler radar system, the terminal Doppler program, in and of itself is about $550 million, a substantial component. Weather-related programs are about $1.2 billion, and I will rely on Mr. Blake to correct me on the specifics for the record.

But it is a very, very important program. We have worked very, very hard—and the difference, Congressman, my early testimony two years ago when we were looking at what was happening at Memphis, I was talking about how we literally had to have meteorologists in the control tower to translate the raw data for it to be usable because some of the questions from Members were, "If we have the technology today, why can't we use it?" It was right after the terrible Delta crash.

But we literally had to have people standing there to interpolate the data, and it was seven, eight, nine, perhaps even ten minutes, which with a microburst is much too late. We now have the system ready for Denver, and operating in Denver, and the software is in such a state that it is doing all that translation now.

So, we have made so much progress in the space of two years. That's why we're so optimistic and confident—more than optimistic—confident that we will contract in 1988.

Mr. MOLINARI. If the Chairman wouldn't mind?

Mr. OBERSTAR. Go ahead.

Mr. MOLINARI. What communications were there from Mrs. Dole on seeking the appropriations? It's kind of unusual. We are perplexed and puzzled here by the turn of events.

Mr. OBERSTAR. And delighted, to some extent.

Mr. **Molinari**. But the question I would have is what has she done historically to make that request known to the Hill? I think if she had, it's hard for me to understand why that money wouldn't have been put forth.

Mr. **Scocozza**. We have communicated our interest to the Appropriations Committee. I am not privy to any conversations Mrs. Dole has had with the Chairman or the Ranking Minority Member, but we have made it clear that we are upset, as my testimony states, cleared by OMB and the FAA, that we are upset about the $130 million—well, it's not a $130 million cut, I suppose it's $120 million—from $130 million down to $10 million.

I am sure that we were asked for our comments on the original subcommittee markup, and we did provide them to the full committee. But I am not privy of any communication from the FAA to the Appropriations Committee that in any way would have suggested that we could live with a $120 million cut or any cut.

Mr. **Oberstar**. We have been talking all day about uplink. Apparently, the uplink didn't work here—[Laughter.]

In getting the message from downtown up here on the Hill to the Appropriations Committee, because clearly the Chairman and clearly Mr. Coughlin, the Ranking Member on that subcommittee, willing to make the funds available, withheld doing so on the specific information that FAA is not prepared to let contracts in fiscal year 1988.

We had testimony earlier today as to whether the FAA was ready to move ahead, and other testimony indicated that well, if that's the case, then clearly, you know, the money shouldn't be made available if FAA is not ready to move ahead. And some felt that perhaps indeed, given the state of development of the system, you're not ready to move ahead.

GAO testified a little bit ago that research is still underway and is to be completed in fiscal year 1988. Is that the case?

Mr. **Scocozza**. I would be—if I could just answer that very generally.

Mr. **Oberstar**. And in what research, then.

Mr. **Scocozza**. Yes. And then defer to Mr. Blake.

As I mentioned to Congressman Molinari, when I started the process two years ago, my first testimony in this area, and now I say, "Well, what's happened that we've made such great strides? Have we just rebuilt the computer?" But basically, the computers are substantially the same. The technology is substantially the same. It's the algorithms, the software that have been improved. So we are continually making changes and improvements, light-years of improvements with respect to the software which will, yes, in fact change. But the basic hardware is the same, and that's why we feel confident it's time to start contracting, and the algorithms will continue to improve. It's a dynamic process.

But being the expert that Mr. Blake is, I would really like him to clarify what I have just said, for the best interests of the record.

Mr. **Oberstar**. Yes. I want to know specifically, Mr. Blake, what research remains to be done, precisely with respect to the terminal Doppler, in the coming year as was referred to by the GAO. I think we need to know what it is yet that remains to be discovered.

Secondly, you have heard us discuss back and forth the dilemma that FAA—that any Federal agency—is in when making judgments to move ahead on a major system. On the one hand you're subject to the criticism you "didn't move fast enough." On the other hand, if you do move, you "didn't think it through carefully enough" and we've "wasted some money." We have been very sensitive to that.

We want to be sure that you are moving ahead with all deliberate speed, but that also the system on which you are moving ahead has been thought through carefully enough to be able to deliver that which is intended, those five points GAO referred to which are the FAA objectives.

Now please proceed.

Mr. **Blake**. Thank you, Mr. Chairman.

As you know, we started with our test bed in Memphis several years ago. The first year we characterized what the microburst looked like from a radar signature point of view. And we also verified through flight tests that when the radar said we had a microburst, there was one there.

The next year, also at Memphis, we processed this data off-line with a detection algorithm and perfected that algorithm.

This past year, in Huntsville, we operated live; that is, we operated in real-time, on-line, with that algorithm and perfected it.

This year we have taken that algorithm that was developed in a moist climate, and we are verifying that it operates in a dry climate. And this concludes the initial algorithm development.

Next year we intend to use it operationally by giving wind shear advisories to the pilots in the Denver area to be sure that the display formats that had been defined are in fact acceptable to the controllers and the pilots.

Now, we have worked this past year with the user community, with the controller community, to define the very specific alphanumeric display to be used in the tower to present the information automatically to the controller to read to the pilot.

We also envision a graphic display—and I think that was mentioned earlier today—which would go to the tower supervisor as an aid in planning runway utilization. It would not, in all probability, go to the actual local controller.

So we believe that we have taken on and solved the majority of the problems.

Now, several other things were mentioned in the GAO testimony, and one was the addition of precursors to give us extended warning time. Now, the existing Algorithm tells you when the microburst is forming along the flight path. We also have learned enough from the meteorology that we will be able to add some of the precursor algorithms in this initial software package that will be implemented both in the Terminal NEXRAD and in the Terminal Doppler Weather Radar.

We will have sufficient processing capability in the machine we specify to subsequently upgrade the enhancement algorithm to provide even longer warning times. But the first algorithm we put in the field will detect the microbursts as they form on and along the flight path.

I believe the GAO mentioned the detection of ninety percent with a false alarm rate not to exceed ten percent. We're able to do that with the basic algorithms at wind shears of about thirty to forty knots and above. With the addition of the precursors, we can do that down to the threshold, which is twenty knots over a four kilometer distance, and we believe we can meet without question the ninety percent detection just as the microburst is starting to form.

Now, with each succeeding scan, our ability to detect the microburst goes up very rapidly to one hundred percent. So we have no questions about our ability first to detect and then to automatically generate a warning.

Mr. OBERSTAR. That is, the research which you have described is the research that is underway and yet to be completed in the coming fiscal year?

Mr. BLAKE. The majority of the research has been completed. What we are testing now——

Mr. OBERSTAR. But it's not research, it's testing the research done?

Mr. BLAKE. The research for the initial software package we believe is complete. What we are doing is validating it in the dry climate of Denver because we found that it worked in the wet climate——

Mr. OBERSTAR. The wet climates, yes, indeed.

Mr. BLAKE. Of Memphis and Huntsville.

Mr. OBERSTAR. I understand that.

Mr. BLAKE. But we will have room in the processor to add additional improvements or enhancements as they come out of the testing program. And Dr. McCarthy spoke to several of those.

Mr. OBERSTAR. What would you be prepared to do in the coming fiscal year? What contracts would FAA be prepared to let?

Mr. BLAKE. Well, as you know, we are taking delivery of seventeen of our NEXRAD units modified for terminal microburst detection. These are very excellent radars. I have viewed both of them operating. And as you know, we are going to down-select within a month.

The Terminal Doppler Weather Radar is going to look very much like the NEXRAD radar but shifted in frequency from S-band to C-band. We had to do that to get frequency allocations, particularly in the high-density areas along the two coasts. The algorithms will be almost identical, modified only to accommodate the fact we are operating in a different frequency band, and it would be for the C-band radar that we would go out on competitive procurement in 1988.

Mr. OBERSTAR. C-band radar is that which you would be contracting for. What is your estimated cost of the total procurement of the one hundred two systems, the terminal Doppler weather radar?

Mr. BLAKE. That is the $550 million.

Mr. OBERSTAR. $550 million for the total systems?

Mr. BLAKE. Yes.

Mr. OBERSTAR. The $130 million would be for the C-band portion?

Mr. BLAKE. $130 million would be the first increment of the $550 million, and it covers twenty-four units, the first year's request.

Mr. **Scocozza**. Mr. Chairman, if you would like, we have a breakout of every component of our weather program in the NAS plan, the $12.5 billion that I mentioned earlier, and it breaks out every component with our expected spending through the end of the plan. If that would be helpful, we would be delighted to provide it for the record and your review.

Mr. **Oberstar**. We do have the NAS plan. And we would like to have that part of it——

Mr. **Scocozza**. It's an easy reference sheet.

Mr. **Oberstar**. To be included at this point in the record.

Mr. **Scocozza**. Yes.

[The information supplied by Mr. Scocozza follows:]

FINANCIAL PLAN

RE&D WEATHER PROGRAM
(000's omitted)

7/7/87

	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991	FY 1992	TOTAL
CWP	28	3,988	6,797	6,400	4,247	1,433	11,567	6,784	7,988	2,071	2,400	53,703
CWP Future Interface							3,124	3,692	2,199	2,207	2,716	13,938
WCP Enhancements								1,728	2,733	1,738	1,644	7,843
AWOS	457	55		124								636
Airborne Wind Shear					625	1,209	1,062	1,064	1,100	1,104	72	6,236
Advanced Wind Shear Sensor Development							519	820	1,125	1,126	1,827	5,417
Wind Shear	53		100									153
LLWAS								2,436	2,263	2,637	3,286	10,622
Terminal Weather Radar			1,908	60		2,139	1,223	1,420	1,932	346	2,359	11,387
NEXRAD	1,856	4,371	8,488	6,012	6,008	1,775	1,906	1,421	808			32,645
Other	2,652	932	623	742	376	1,036	886	232	534	2,884	536	11,433
TOTAL	5,046	9,346	17,916	13,338	11,256	7,592	20,287	19,597	20,682	14,113	14,840	154,013

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ADL-12 7/1/87

F&E FINANCIAL PLAN FOR WEATHER PROGRAMS - F&E
($ In Million)

PROJECT TITLE	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	Total
Flight Service Automation System (FSAS)	18.9	54.2	31.0	16.4	1.2	34.6	55.9	47.1	18.7	10.0		288.0
Central Weather Processor (CWP)			26.0			20.6				57.3		103.9
Weather Message Switching Center (WMSC)	0.5	12.8		2.2	2.4		5.0					22.9
Weather Communications Processor (WCP)							17.0					17.0
High Altitude En Route Flight Advisory Service (EFAS)				5.3								5.3
Hazardous In-Flight Weather Advisory Service (HIWAS)		3.8	3.5									7.3
Automated Weather Observing System (AWOS)		2.3		10.0	27.2		13.5	50.4	40.4		55.0	198.8
Geostationary Operational Environmental Satellite (GOES)	1.9											1.9
Low Level Wind Shear Alert System (LLWAS)		7.8			19.9	6.2		14.9	5.0			53.8
Next Generation Weather Radar (NEXRAD)			2.0	7.5	4.3	112.4 1/	58.7 2/	46.6	32.0			263.5
Terminal Doppler Weather Radar (TDWR)					7.0		130.0	122.2	202.8	88.0		550.0
TOTALS	21.3	80.9	62.5	41.4	62.0	173.8	280.1	281.2	298.9	155.3	55.0	1512.4

1/ includes 80.[illegible] for Terminal Nexrad

2/ includes 22.5 for Terminal Nexrad

Mr. **Oberstar.** I think it's very important to be precise about what it is the FAA plans to procure and to get that information. I shall seek out the Chairman of the Subcommittee on Transportation and Mr. Coughlin. Perhaps Mr. Molinari will join me in doing so, to discuss this with them so that they are prepared to receive the Secretary's request.

Before going on to Mr. Molinari—I have exceeded my own time already—what is the status of the ASR-9 radar program, Mr. Blake?

Mr. **Blake.** The ASR-9, we will receive our first deliveries in fiscal year 1987, shortly. We will continue to receive deliveries over the next several years. The final unit will be delivered in 1991.

Mr. **Oberstar.** Thank you.

The gentleman from New York, Mr. Molinari.

Mr. **Molinari.** I had a number of bits of information relating to Eastern Airlines, one of which deals with the fact that they have closed their meteorology department. I have talked to some pilots who say that, as a consequence, on flights from South America, it's very, very difficult to obtain weather information. On domestic flights, we have heard all day long about the difficulties that some controllers have in giving weather information when requested.

What do you know about this, and what impact do you believe this would have upon its pilots and the pilots' performance when they have weather problems?

Mr. **Scocozza.** Would you comment, Mr. Blake?

Mr. **Blake.** As a part of an economy move on a number of airlines, they have in many cases closed down their own meteorology departments. However, all of them that have done that have contracted for commercial services. And yes, there were a few problems during that transition, but I believe that most of them either have been fixed or will be fixed shortly.

Mr. **Molinari.** Do you know offhand or can you give us some idea of the carriers that have disbanded their departments in addition to Eastern?

Mr. **Blake.** I'm sorry, I didn't bring that list with me.

Mr. **Molinari.** Is it extensive?

Mr. **Blake.** You will find it more extensive in the smaller commuter carriers. The major airlines, some of them continue to have their own meteorology staff, but those that have converted to commercial services have been quite pleased with them after some initial shakedown periods.

Mr. **Molinari.** How about FAA's policy with respect to using their own meteorology departments as opposed to contracting out? Is there any policy in your department?

Mr. **Blake.** Yes. The airlines must come to us and indicate to us what their plan is for providing weather to the dispatcher and through the dispatcher to the pilot, both in the preflight briefing and while that pilot is en route; that is, flying the system. And they must show us that they have radio frequencies available, usually through ARINC, which is the supplier of radio services to the airlines, whereby they can then get these hazardous weather messages to the flights.

Mr. **Molinari**. So that in each and every case, whatever the carrier, FAA has approved the substitution source of weather information?

Mr. **Blake**. That's correct. Not only the source, but the total method of disseminating weather to the pilot.

Mr. **Molinari**. Turning to the next subject, we have received a number of complaints with regard to Eastern Airlines. I don't know whether this is related to the labor-management problem that exists today with Eastern—it's hard for us to be able to sift through, and I am sure you have the same problem trying to determine what may really be serious but we have a number of complaints regarding their weather radar on the Boeing 727 aircraft. There is a process that they call the weather radar system adjustment. This test is not a bench test of the 23 TR 139 TR unit, which is the weather unit, as I understand it, nor was it ever intended to be used as such.

Now, there is a procedure to test weather radar, and that is the Bendix bench test. The mechanics are alleging that Eastern Airlines is not using the process.

Are you aware of these allegations, Mr. Scocozza or Mr. Blake?

Mr. **Scocozza**. No, I am, not, Congressman. This is new to me.

Mr. **Molinari**. Mr. Blake, you are not either?

Mr. **Blake**. No. But I will certainly bring it to our aviation standards department's attention, and we will look into it.

Mr. **Molinari**. Well, I would appreciate it if you would not only do that, but if you would then send a communication to me telling me what the findings of your inquiry might be, because my understanding is that what they are doing is going on board and testing the equipment rather than pulling the equipment out and bringing it into the avionics shop where apparently they would be able to do a better job. That could be quite critical, so we would like to get a good fix on that.

[The information provided by Mr. Blake follows:]

The Office of Flight Standards checked with the regional and flight service district offices to ascertain the circumstances related by Representative Molinari. They were unable to identify the specific event as described by the Congressman. The FAA has, however, received a large number of incident reports from Eastern Airlines mechanics and pilots, which are currently being investigated. The majority of these reports are anonymous and lack specific references that would facilitate a complete investigation. Where aircraft registration numbers have been included, our flight inspectors are taking appropriate followup action. Since, to date, all of the incident reports have not been received, Office of Flight Standards personnel in the region and the flight service district office will be on the lookout for the incident reported by Representative Molinari.

Mr. **Molinari**. One other area of concern, getting back to the dollar figures that the Chairman talked about before, are you prepared to say on the record today that you will be able to spend that $130 million in fiscal year 1988?

Mr. **Scocozza**. Yes, Congressman, we are confident that we can.

Mr. **Molinari**. Okay. We have one last series of allegations in one particular case I am looking at here, a letter that a pilot sent to us stating that during a flight from JFK to Sarasota, the aircraft's weather radar system faulted. The pilot asked the Eastern Airlines dispatch facility in Miami to alter the flight plan because of thunderstorm activity in the Sarasota area.

The management allegedly refused, stating, in part, that the requirement—the FAA requirement—for operative weather radar was merely a legal requirement for dispatch, and that in effect once the plane was airborne, they had met the test. In effect, they were ordering this pilot to proceed with the flight plan and to land in Sarasota.

Is that the position of FAA, as articulated by this management representative of Eastern Airlines?

Mr. SCOCOZZA. We would have to get the specifics on that particular case, Congressman. But my response generally, with the knowledge that I have, is that doesn't appear to be the standard operating procedure. I can't imagine as a standard practice, the pilot being ordered not to divert if the equipment and weather required such.

But I will get back to you on that specific instance and the policy in general.

Mr. MOLINARI. Yes.

[The information supplied by Mr. Scocozza follows:]

With regard to the incident involving failure of a radar during flight, the pilot took the appropriate action. Further, it is the pilot's responsibility, not the dispatcher's to make the decisions affecting safety of flight. We have checked with our regional office and are unable to locate the letter which the pilot, referred to by Representative Molinari, is alleged to have written to the FAA.

Mr. MOLINARI. The reason I ask the question, frankly, is because this pilot had communicated with FAA several months back and told of the problem. Eventually, on his own, he refused to fly and flew to, I think, Atlanta, where there were no other problems, and landed his plane. But as of a day or two ago, he had received no response whatsoever to his communication.

Obviously, if this is happening, we are having a very serious problem out there with respect to maybe that one carrier. But I think it should be looked into and we should know whether that is an isolated case or whether that is the policy of that particular carrier and what's being done about it.

Mr. SCOCOZZA. The general rule of thumb that I have used, Congressman, in response to similar situations is that the pilot is literally the captain of the ship, and we respect that. And if the pilot, before he takes off, walks around the plane, if there is anything about the plane he believes or she believes is not within the Federal Aviation Regulations or whatever, that plane does not take off. And we stand immediately behind the pilot so there is absolutely no reprimand.

And we have a series of programs where there can be anonymous calls to the Department of Transportation to alert us to similar situations.

Mr. MOLINARI. I am aware of all that, and that is what we have been told many times. It is only now in the last six months or so, and I guess it is tied into this labor-management struggle. But what I am suggesting or what they're suggesting is that maybe not all the pilots have the final say anymore, that with some carriers—and the allegation here is that it's Eastern Airlines—the pilots are not as free to make that determination; if they do, they could be threatened with the loss of their job.

I had a call some six months ago from an Eastern Airlines pilot unrelated to any of this coupon-writing that is going on now and that kind of thing, talking about a near-midair collision, and that when he landed he was talked out of filing a near-midair collision report by the FAA management operator in the Miami, Florida facility.

I was terribly disturbed when I heard that, and asked him if he would appear before our subcommittee. He said he would be delighted to; he would be happy to tell his story because he was deeply concerned about it.

I asked him why he didn't file. He said, well, you know, they told him that they were doing the best they could, that everybody was working hard, they were short-staffed and all that, and he felt sorry for them.

A couple of days later I couldn't get that pilot to talk to anybody because he talked with fellow pilots and was told that he would lose his job if in fact he spoke. This was after three or four conversations.

So it does happen out there. Some of these pilots are no longer in charge of their ships. They are receiving instructions, and I think we might have witnessed that Friday night, as I alleged earlier.

We see some planes take off, as I mentioned earlier today, leaving Washington National and then suddenly being told they've got to set down in Baltimore. I don't know why a plane flies such a short distance and is told to set down; why there isn't better weather information in a situation like that. It goes right to the heart of our hearing here today. I was puzzled by it. There may be a very good and logical explanation for it. It might have been something unforeseen. But there were a lot of people that waited long periods of time as a consequence.

[The following was received from Mr. Scocozza:]

With reference to Representative Molinari's assertion that a plane departed Washington National Airport enroute to Newark but had to divert to BWI, due to inadequate weather information, the facts are as follows:

On June 26, at approximately 4 P.M., EDT, a severe weather system moved into the East Coast which had a serious impact on flight operations within the New York and Washington, D.C. metropolitan areas. The National Weather Service reports indicated reduced ceilings and visibility, thunderstorms, and heavy rainshowers with slow frontal movement north and northeast. The weather condition remained in effect until approximately 10 P.M. EDT.

Inquiries through the Continental Airline Operations Offices at Washington National and Continental Corporate Offices in Houston indicated that of the six flights originally scheduled to depart Washington National for Newark, after 4 P.M., on June 26, five were cancelled due to weather conditions. The sixth flight departed Washington National at approximately 9 P.M. and arrived Newark nonstop. Continental Airlines and FAA records indicate that no Continental flights enroute to Newark from Washington National were diverted to Baltimore-Washington International (BWI) on June 26.

Representative Molinari may have heard about Continental flight No. 319 enroute to Washington National from Newark, which because of the weather, diverted to BWI at the decision of the pilot-in-command. If flight No. 319 had arrived Washington National, it would have returned to Newark as Continental flight No. 322.

Mr. Scocozza. In any event, let me close by saying that I wish that you people would give these matters a little special attention. I have corresponded with Mrs. Dole on this score so that we don't dismiss some of these charges simply because there might be other unrelated problems out there. It is a matter of very deep concern to me.

Mr. Scocozza. I would say, Congressman, if these turn out to be true, actual situations that occur, that pilot certainly won't lose his position or her position, whatever the case might be. But perhaps someone in the FAA will lose their position if there was any intimidation to not report a legitimate occurrence. This is a very, very serious situation.

Mr. Molinari. The intimidation, I think in that case, in fairness, did not come from the FAA representative. The FAA representative tried to influence the pilot not to file a report, in a very nice way, saying, "We're busy. We're doing the best we can, and I'd appreciate it if you didn't file it." And the pilot was sympathetic. The intimidation occurred as a result of conversations with other pilots at Eastern Airlines, that if he appeared publicly and said it, that he'd lose his job. Then he clammed up and wouldn't talk any more thereafter. So it isn't the FAA's total blame. There was some blame there. I don't think any representative of the FAA should try to talk somebody out of filing a near-midair collision report.

Mr. Scocozza. Absolutely not.

Mr. Molinari. That is critically important, that information, to all of us.

Mr. Scocozza. Because the FAA has a responsibility to accurately report all of these particular situations.

Mr. Molinari. They sure do.

Mr. Scocozza. As the pilot sees them.

Mr. Molinari. You sure do. We've been through that one before. But I appreciate your cooperation.

Mr. Scocozza. Sure.

Mr. Oberstar. I thank the gentleman for that line of questioning and for raising that incident of last Friday night. I think it's extremely important, and we expect a report from the Department to the subcommittee as well as to Mr. Molinari directly.

The gentleman from Georgia, Mr. Rowland?

Mr. Rowland. Thank you, Mr. Chairman.

I apologize for not being here for all of your testimony, which I understand was very good.

One thing that I have been interested in is the transmission of data from the ground to the pilots in a usable condition. The Mode S transponder, as I understand it—GAO has said it could not be used for that. But I believe perhaps FAA has said that it could be used for that.

So I am interested in knowing how we resolve that difference of opinion, or is it resolvable? Could you comment on that a little further?

Mr. Scocozza. We believe very strongly, Congressman, that the Mode S transponder will do a fine job, perhaps better than GAO believes.

At the initial stages of the implementation of the Mode S transponder program, a lot of the routine information will be plugged into that system, where some people will say, "Well, that doesn't really do you that much good because the air traffic controller has to supplement it." But the Mode S transponder does have the capabilities of plugging in much more sophisticated information to free up the air traffic controller.

I would like Mr. Blake to get into the issue from a technical standpoint for you.

Mr. **Blake**. Yes. The early products will be the ones available from the weather network; those will include Sigmets, which are the severe weather warnings, and we can add to those any alphanumeric messages such as the wind shear type of warning that was talked about earlier.

Now, it was also mentioned that the Central Weather Processor and the Weather Communications Processor are key elements in getting graphics transmitted to the cockpit. The schedule on the CWP says early- to mid-1990's, 1993 to 1995. So that gives you the time period in which we would be able to take radar graphic information and transmit it by data link to the pilots.

Mr. **Rowland**. Let me ask you this. Will it transmit thunderstorm and wind shear information, which is what we are principally interested in?

Mr. **Blake**. There will be two formats for that. One is the alphanumeric format, the one that Dr. McCarthy showed, which tells you the type of wind shear event, where it is, what the severity of it is, and whether it's increasing or decreasing. Yes, that can be transmitted.

The other product that we would see coming later would be a graphic product that showed you a geometrical form of a wind shear area that says within this circle or hexagon is a wind shear with a magnitude of fifty or sixty knots. And we would not, as was suggested by one of the witnesses, transmit the very pretty color radar picture that was also shown by Dr. McCarthy. We would extract from that the automatically generated wind shear product or the gust front product or the tornado or the hail symbol, and transmit that in a way that it could be put on display in the aircraft instrument panel, presumably a radar display.

Mr. **Rowland**. When will this technology be available? You mentioned two, one, and then a substitute. When will that be available?

Mr. **Blake**. The initial alphanumeric capability we hope to bring up with Mode S in 1990. The graphic capability would come in the 1993–95 time period, when we have the processors in place to supply the information.

Mr. **Rowland**. Thank you very much.

Thank you, Mr. Chairman.

Mr. **Oberstar**. Thank you.

Mr. Blake, one of the objectives of the NAS plan is to provide weather information directly to pilots. And I have expressed concern in the past, and so has GAO—and they testified on this matter earlier today—about overloading controllers with too much work. We know that we aren't at full strength. We know that we need more controllers and more FPL's in the work force.

In the interim, aren't we—between now and full operational status of the terminal Doppler weather radar system—isn't there a concern that you'll add another level of responsibility to the controller workload and don't you—I should put it this way: do you have some training contingencies or plans in the works to deal with that issue of controller workload?

Mr. **Blake**. Well, our objective is clearly to unload the controller of the weather dissemination task to the extent you can.

Mr. **Oberstar**. A very important objective.

Mr. **Blake**. And we have implemented in three centers and will complete in 1988 the implementation of the HIWAS system. That is the Hazardous Inflight Weather Alerting System. We have also upgraded that system to include center weather advisories that are generated by the National Weather Service meteorologists in our air traffic control centers. So that will be a much better real-time severe-weather product than we have had in the past.

We have made other changes. We have changed the automatic terminal information service weather format to include remarks. So not only does it tell you wind direction, velocity, ceiling, and visibility, but it will tell you about "thunderstorms northwest" or "cumulonimbusall quadrants" or whatever the normal remarks would be. And we have been working with the weather observer that services these major airports to be sure that they keep those weather observations updated on a timely basis, and they do note significant weather that can be seen in the vicinity of the airport.

So this again is a further improvement in the weather service directly available to the pilots.

The one service that will remain for the time being on the terminal controllers' displays—and these are the special alphanumeric displays—will be the dissemination either of the Low-Level Windshear Alerting System output or the output of the Terminal NEXRAD or its Terminal Doppler Weather Radar equivalent.

Until we have substantial data link implementation, the controller will have to read those alerts, when they appear, to the pilot on a secondary basis; that is, keep the airplanes apart first, but be sure you give them the weather advisory.

Mr. **Oberstar**. It is very simple to say, as I have heard many times, well, why not have the controllers provide this information to the pilots? Well, they are so busy. You know, many of the folks who say that just don't understand what's going on in the towers and in the centers and in the tracons, how much workload they can handle. If you are on track, as you have testified, we certainly find that encouraging toward relieving the controller of that level of responsibility.

But at least in the interim it seems that not only the Doppler information is going to have to be transmitted, other information before we get to an automated system, but probably the ASR-9 as well.

Mr. **Blake**. We have run some experiments in several control towers on how that information would be used. And the major use that we have been making of that type of data is a planning aid to the supervisor who determines what runway configuration to use and how to adjust the traffic patterns to avoid the areas that are occupied by severe weather.

So it is not the controller that is actively handling each aircraft that is studying contours, but the supervisor who is setting up the traffic flows that gets the most benefit from them.

On the other hand, if a general aviation aircraft calls in and asks to be vectored around the precipitation, the controller will have on his display a very accurate contour of where that precipitation area exists.

Mr. **Oberstar**. Does the FAA have any objection in principle to development of airborne weather detection systems?

Mr. **Blake**. No. We have, as you know, as Cecil Rosen testified earlier, we have entered into a research project with NASA to determine whether it is feasible to develop a combined airborne Doppler weather radar and airborne LIDAR, which is the laser equivalent, and to combine that with the flight guidance systems on the aircraft. This is a five-year program and we are in the second-year program now.

We hope to have the feasibility studies and analysis completed by February of 1988. If it looks good, we would proceed then to develop one or more prototypes, one of the radar and one of the LIDAR, and have units available to test, I would say, sometime in 1991.

So this is a long-term effort. I think you have heard almost everyone say today that if we could invent this thing and make it work, that it would be preferable in that it would provide protection at all airports where the larger aircraft would operate—and we're talking large aircraft because this is a lot of equipment that we are now adding to the basic airframe. But we are very aggressively and so is NASA very aggressively pursuing this to see if it's feasible.

Mr. **Oberstar**. You are in agreement with the objective of development of an airborne system, participating, cooperating with NASA, providing funding and committing funds. You have an objective of February of 1988 to decide whether to go ahead with testing of a system? Is that correct?

Mr. **Blake**. That's correct, yes, sir.

Mr. **Oberstar**. Well, that is very encouraging to hear. We are very glad to hear that. We compliment you. Keep on track.

But NEXRAD has experienced considerable delay. We had testimony earlier, not only in our committee but another committee that you have testified before, that NEXRAD had slipped one year due to underestimates of the time necessary for evaluation of the prototype. There have been further delays.

Could you tell us more? Be specific about what has been the nature of the delay, what is the current status. We have already discussed that in some broad terms, but be specific about where we stand and where you envision NEXRAD moving. And are you talking about the software, hardware? Differentiate between the two.

Mr. **Blake**. The original award had been planned for February of 1987, and we did slip it to the end of July 1987. We did that based on the results of the initial IOT&E test conducted for us by the Air Force AFOTEC organization, and that is their independent test and evaluation group.

We felt that neither contractor in the test conducted last fall had quite reached the point where we could make a down-select. Since that time, they have substantially improved their systems, and we have met—the three agencies have met and decided to go ahead with the selection of the production, first of all a limited production, but also the production contractors.

So the contractors have gotten on top of the majority of the problems they had and solved them.

Mr. **Oberstar**. And you feel confident you can move ahead now with a production contract?

Mr. **Blake**. Yes. We have been able to look at the base weather products and have them evaluated by meteorologists and the evaluation was satisfactory. So I think we're ready to move ahead.

Mr. **Oberstar**. What was the deciding factor? Was that the resolution of the problem with the algorithms?

Mr. **Blake**. Well, it's a variety of very small problems, hardware problems in a transmitter or hardware problems in an interface, or a printer would hang up the display when it was printing things out. Nothing of a major category, but we still felt that the majority of these small problems had to be cleaned up if we were to make a complete evaluation, and the majority of them have been.

Mr. **Oberstar**. We heard testimony earlier today that the Mode S system is not versatile enough to accommodate this advanced technology and that it is a major problem in the development of wind shear and other weather problem detection. What is your response?

Mr. **Blake**. Well, I think that the point that was made was that the link was not sufficiently robust or had sufficient capacity to send raw radar pictures to the cockpit. And FAA a long time ago made the determination that we were not going to do that, that we would send processed hazard information in graphic form to the cockpit, which is really what the pilot needs. He wants to know where that wind shear is located with respect to his navigation map, where the hail area is, where the heavy precipitation area is. And we believe that we can transmit these contours via Mode S to the cockpit without overloading the link.

Mr. **Oberstar**. One of the questions was whether Mode S would be able to put up the graphics, as they say in the popular lexicon of that terminology. What is your response?

Mr. **Blake**. Well, we will put up graphic representation of the location of the severe weather areas. We will not put up the full color radar display, the raw radar information. We think that may actually degrade safety because the pilot now, instead of flying the airplane, is trying to figure out what the raw radar is telling him.

Mr. **Oberstar**. The gentleman from New York had some further questions?

Mr. **Molinari**. Just one last question, Mr. Chairman.

How much weather training does a trainee at the Oklahoma City academy receive?

Mr. **Blake**. Well, I think really the question is more appropriate for a weather coordinator because that is the air traffic person that is responsible for taking the meteorological products and disseminating them to the appropriate control sectors in the center and to the appropriate tracons and towers; that is, those that would be affected by the particular weather warning or center weather advisory.

We do have two training programs for them, one in the facility which is conducted by the meteorologists, and another one that is conducted at Oklahoma City, that provide the training to the person whose responsibility is primarily weather coordination.

Mr. MOLINARI. I am more interested in the academy, for a specific reason. I am trying to find out from you, if you know, how many hours and——

Mr. BLAKE. Oh, I don't know the course hours, but we could certainly look that up.

Mr. MOLINARI. All right. The reason I ask the question is because we are receiving reports that there has been a reduction in the amount of training that is given to controllers in the area of weather and weather information.

That has me concerned because obviously we have heard all day about the problems that we have with controllers giving that information to pilots who need it. But if there is a cutback in training at the academy, then we've compounded a problem that is already serious. And I am wondering if you have any awareness, either of you gentlemen, as to what that situation is.

Mr. BLAKE. Well, I believe that the problem really related to the weather coordinator training, and that course has been reestablished. I think in our last hearing we recognized the need to do that. And I think the problem has been corrected.

Mr. MOLINARI. The information I have received is from instructors who are saying that they are deeply concerned because they're not giving as much as they did before. And frankly, what they said is that the amount they were giving before was rather sparse, and to cut back on that base information had this instructor very, very much concerned.

It's difficult for me to evaluate, but obviously it would be something that would concern me, and I would hope, concern both of you. Maybe you can check it out.

Mr. SCOCOZZA. Congressman, I have made a note to get back to you with the specifics and any changes in curriculum regarding weather training at the academy for all categories of people we put through there, and, if there have been any changes, an explanation of why.

Mr. MOLINARI. Fine. I appreciate that.

Mr. SCOCOZZA. Sure.

[The information supplied by Mr. Scocozza follows:]

In 1980 the air traffic control training program was modified so that all three options could attend a common Phase II training, which included weather training. Because flight service specialists require more in-depth weather training, this training was designed to meet their needs.

With the implementation of the National Air Traffic Screen, Placement, and Training (NATSPT) program, aviation weather training was revised to reflect the needs of each specific air traffic control option. Because of their unique job demands, flight service specialists receive more weather training than terminal controllers and terminal controllers receive more weather training than en route conrollers.

In February 1987, the enroute and terminal option were separated from the flight service option. The flight service option retained the Phase II program. Relevant course content for the enroute and terminal programs has been redistributed throughout the NATSPT.

The Phase II program for students in the flight service specialist option consist of 26 hours of weather training covering 425 pages of material. Terminal students now receive 23 hours of weather training covering 522 pages of material, and enroute students now receive 12 hours of weather training covering 288 pages of material.

Mr. MOLINARI. That is all I have, Mr. Chairman. Thank you.

Mr. OBERSTAR. Thank you.

A final point of inquiry on the center weather service units. They were established by the FAA at each of the en route centers to provide weather information to controllers and obviously for aircraft under their control, and are staffed by the National Weather Service personnel. FAA provides the equipment. Is that state-of-the-art equipment? How would you describe it?

Mr. BLAKE. We have provided them with all the standard weather products, with the GOES satellite pictures, and with the remote radar display system. We are looking at the possibility of upgrading some of this equipment through the use of commercial services that make some of the standard weather service products available in color graphic form.

We have already taken that step for the en route flight advisory positions in the major flight service stations, and they are going ahead with that procurement. And we are looking now at establishing a similar program to upgrade the center weather service unit equipment.

Mr. OBERSTAR. Are personnel that the National Weather Service provides trained in aviation, or is that not a requirement for bidding on those positions?

Mr. BLAKE. They have aviation training, not only the ones that work on our centers, but the ones that prepare terminal forecasts in the National Weather Service centers and that prepare area forecasts, which is in the National Severe Storms Group in Kansas City. So they do receive some aviation training.

Mr. OBERSTAR. All right.

Mr. BLAKE. Specifically so they can forecast products of interest to aviation. That would include turbulence aloft, winds aloft, terminal forecasts, things that are very specific to our needs and are not of interest to the general public.

Mr. OBERSTAR. Do you frequently get former military weather forecasters in those positions?

Mr. BLAKE. We have had some, although I think that is changing now.

Mr. OBERSTAR. How many hours a day do the units operate?

Mr. BLAKE. I think we're running two shifts at the present time, 16 hours.

Mr. OBERSTAR. We had testimony earlier today from NTSB about the Delta crash at Dallas, in which it was stated that the unit was not operating at the time of the crash, that the operator was out to lunch. It just happened to be that person's lunch hour. Not negligent in any way, just happened to be that person's lunch hour.

In the wake of that incident, what steps has FAA taken to assure that lunch hour is covered?

Mr. BLAKE. Well, a meteorologist doesn't get any lunch if he is alone. And some of them have more than one meteorologist on duty. But the meteorologist, if there is significant weather, does not leave the center weather service unit.

Mr. OBERSTAR. Apparently in this case, that happened.

Mr. BLAKE. Well, in his judgment, there was no significant weather at the time he left to eat. And that was in fact true, that we had a lot of low-intensity precipitation contours in the Texas area that day, but none on major storm activity, and he felt in his judgment that there was no significant weather.

Now, obviously there has been a lot of discussion since that time to be sure that that situation is taken care of.

Mr. **Oberstar**. As I said, the NTSB did not allege any negligence on their part.

Mr. **Blake**. There was none. That's correct.

Mr. **Oberstar**. Clearly, that's not the case. But we have had throughout today's testimony and in the past—the record is replete with instances in which it appears that there is no adverse weather condition and all of a sudden it develops.

Mr. **Blake**. It develops.

Mr. **Oberstar**. So there needs to be that extra measure of protection.

Mr. **Blake**. Well, I think that's a point that was very, very heavily considered when we bought the NEXRAD systems, that there be an automatic warning system built into that radar, so even if the meteorologist were momentarily looking away from the scope, if significant weather started to develop—and these microbursts do develop rapidly—his attention would be called back and the phenomena pointed out. That is one of the things that we have done to make sure we have very rapid response.

The other thing we've done, of course, is to make the reporting of these very severe microburst conditions automatic. If the man happens to be away for a minute, the report goes out in real time.

Mr. **Oberstar**. Yes. Well, that's exactly critical. Dissemination and communication, detection, dissemination, communication. Critical points, if we have learned anything from these hearings.

Do you feel that those units are adequately staffed? Maybe I should put it this way: are the units adequately staffed?

Mr. **Blake**. I think they are adequately staffed during the two shifts that we operate them. We do not operate the third shift as we don't have much traffic and we don't have much weather develop in the early morning hours. There has been some discussion about whether it was advisable to staff them additional time. And I know that in our in-house meetings we are considering the very question you asked, as we do consider it extremely important to keep those positions manned.

Mr. **Oberstar**. We will follow with continuing interest your deliberations on that matter. We want to be sure that there is a need, that it is met, that whatever financial resources are necessary to assure that measure of safety in fact will be provided.

Thank you very much, Mr. Secretary, Mr. Blake, for being with us for that very important development that arose from your testimony. We shall follow through promptly as we indicated. It has been a very useful hearing, a very important milestone in our subcommittee activities. We greatly appreciate the testimony all witnesses have provided today.

[The prepared statement of Mr. Scocozza follows:]

STATEMENT OF MATTHEW V. SCOCOZZA,
ASSISTANT SECRETARY FOR POLICY
AND INTERNATIONAL AFFAIRS
DEPARTMENT OF TRANSPORTATION
BEFORE THE HOUSE COMMITTEE ON PUBLIC WORKS AND TRANSPORTATION
SUBCOMMITTEE ON INVESTIGATIONS AND OVERSIGHT
JUNE 30, 1987

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE:

I APPRECIATE THE OPPORTUNITY TO APPEAR BEFORE THE SUBCOMMITTEE TODAY TO DISCUSS FAA AND RELATED FEDERAL PROGRAMS INVOLVING WEATHER DETECTION, COMMUNICATION OF THE RELEVANT DATA, ITS PROCESSING AND INTERPRETATION, AND ULTIMATELY THE DISTRIBUTION OF THE INFORMATION TO AIR TRAFFIC CONTROLLERS AND PILOTS. AS YOU KNOW, AVIATION WEATHER IS A COMPLEX AND HIGHLY TECHNICAL SUBJECT, INVOLVING BOTH THE DEVELOPMENT OF WEATHER PRODUCTS AND THE SYSTEMS FOR CONVEYING THE KEY FACTS AND FIGURES TO THOSE WHO NEED THEM. WITHOUT GETTING BOGGED DOWN IN DETAIL, I WOULD LIKE TO OUTLINE FOR THE SUBCOMMITTEE OUR PROGRESS TO DATE ACROSS A BROAD AND VITALLY IMPORTANT SPECTRUM OF WEATHER-RELATED ACTIVITIES.

IT WOULD PROBABLY GO WITHOUT SAYING THAT ADEQUATE WEATHER INFORMATION IS ESSENTIAL TO SAFE FLIGHT--ESPECIALLY DURING THE CRITICAL TAKE-OFF AND LANDING PHASES. ALTHOUGH WINDSHEAR AND ICING CONDITIONS RECEIVE THE MOST ATTENTION IN THIS REGARD, OTHER FACTORS SUCH AS GUST FRONTS, AIRPORT VISIBILITY, AND EVEN TEMPERATURE COULD BE CAUSE FOR CONCERN. OBVIOUSLY, BAD WEATHER IN THE EN ROUTE PHASE CAN THREATEN EVEN THE LARGEST COMMERCIAL

AIRLINER, IF EXTREME TURBULENCE, HAILSTONES, OR DOWNDRAFTS ARE PRESENT. ALL TOO OFTEN WE GET GRIM REMINDERS OF HOW CRUCIAL TIMELY AND ACCURATE WEATHER REPORTS ARE, OR SHOULD BE, TO GENERAL AVIATION PILOTS WHO DO NOT HAVE INSTRUMENT RATINGS.

IN ADDITION, ADVERSE WEATHER IS RESPONSIBLE FOR A MAJORITY OF THE AIRLINE DELAYS THAT HAVE RECEIVED SO MUCH PUBLICITY IN RECENT DAYS. THE MORE INFORMATION AIR TRAFFIC CONTROLLERS HAVE, THE BETTER THE CHANCE OF MINIMIZING THOSE DELAYS BY REROUTING TRAFFIC, ASSIGNING IT TO HIGHER ALTITUDES, OR ORCHESTRATING "GROUND-HOLDS." COCKPIT CREWS AND THE AIR CARRIERS THEMSELVES CAN MAKE GOOD USE OF NEAR-REAL TIME OR FORECAST WEATHER DATA IN CONDUCTING THEIR DAILY OPERATIONS WITH MAXIMUM EFFICIENCY. NORTHWEST IS ONE OF SEVERAL AIRLINES WITH A SIZABLE METEOROLOGICAL STAFF TO PROVIDE ADVISORIES TO ITS MANAGERS AND AIRCRAFT.

NONE OF THIS IS TO SAY THAT AIRLINE PASSENGERS SHOULD BE CONCERNED ABOUT WEATHER. THE AVIATION SYSTEM, INCLUDING AIRCRAFT, AIRPORTS, AND AIR TRAFFIC CONTROL, HAS BECOME SO SOPHISTICATED OVER THE YEARS THAT FLIGHT IN INCLEMENT WEATHER IS A ROUTINE OCCURRENCE. SUCH AIR TRAVEL HAPPENS EVERY DAY WITH NO DEROGATION OF SAFETY. OUR ONLY POINT HERE IS THAT SOME KINDS OF WEATHER SHOULD BE AVOIDED, DEPENDING ON THE NATURE OF THE OPERATION, TO ENSURE THAT PASSENGERS AND CREWS ARE NOT EXPOSED TO UNDESIRABLE LEVELS OF RISK.

MOST METEOROLOGICAL DATA ARE COLLECTED BY THE NATIONAL WEATHER SERVICE, FAA, DEPARTMENT OF DEFENSE, AIRLINES, AND CONTRACT

OBSERVERS, AND THE ACQUISITION METHODS INCLUDE SURFACE OBSERVATIONS BY PERSONS OR SENSOR EQUIPMENT, UPPER AIR SOUNDINGS, RADAR DATA, AND SATELLITE RETURNS. FAA STILL TAKES ABOUT 30 PERCENT OF THE SURFACE OBSERVATIONS WITHIN THE CONTINENTAL UNITED STATES AND DISSEMINATES PILOT REPORT (OR PIREP) INFORMATION NATIONWIDE. THE WEATHER DATA ARE USUALLY TRANSMITTED FROM ONE PARTY TO ANOTHER VIA MEDIUM-SPEED EQUIPMENT KNOWN AS LEASED SERVICE A AND BY LOW- AND MEDIUM-SPEED FACSIMILE SYSTEMS. THE HEART OF THE AVIATION WEATHER SYSTEM'S COMMUNICATION NETWORK IS THE WEATHER MESSAGE SWITCHING CENTER LOCATED IN KANSAS CITY.

UNFORTUNATELY, THE AVIATION WEATHER SYSTEM IS NOT WITHOUT ITS PROBLEMS. FOR EXAMPLE, THE WHOLE OPERATION STILL TENDS TO BE MORE LABOR INTENSIVE THAN THE VARIOUS AGENCIES WOULD LIKE. ALSO, WHEN SERVING AS A MIDDLEMAN FOR CONVEYING INFORMATION TO A PILOT, THE CONTROLLER HAS TO GIVE FIRST PRIORITY TO SEPARATING TRAFFIC AND MAY NOT HAVE ENOUGH KNOWLEDGE TO ANALYZE ALPHANUMERIC OR GRAPHIC MATERIAL ON CURRENT WEATHER. IN 1986, THE GENERAL ACCOUNTING OFFICE EXPRESSED PARTICULAR CONCERN ABOUT WEATHER CAPABILITIES IN TOWERS AT THE NATION'S MAJOR AIRPORTS, AND IS COMPLETING A DETAILED STUDY OF FAA'S AVIATION WEATHER SYSTEM DEVELOPMENT PLANS. IN SHORT--NOTWITHSTANDING THE MANY ACHIEVEMENTS WE CAN ALL BE PROUD OF--PROJECTS THAT WILL PRODUCE MORE AND BETTER DATA, PASS IT ALONG MORE QUICKLY, AND MINIMIZE THE AIR TRAFFIC CONTROL WORKLOAD MUST CONTINUE.

THESE ARE EXACTLY THE PROBLEMS THAT FAA'S WEATHER PROJECTS ARE DESIGNED TO ADDRESS, BUT, BEFORE DISCUSSING THEM, LET ME BRIEFLY TOUCH ON SOME OF OUR RECENT AND MORE SUBSTANTIAL ACCOMPLISHMENTS:

- WEATHER RADAR INFORMATION FROM FAA AIR TRAFFIC AND NWS RADARS CAN NOW BE DISPLAYED IN READABLE COLOR IN FLIGHT SERVICE STATIONS AND AIR ROUTE TRAFFIC CONTROL CENTERS, THANKS TO INSTALLATION OF RADAR REMOTE WEATHER DISPLAY SYSTEMS;
- EN ROUTE FLIGHT ADVISORY SERVICE NORMALLY AVAILABLE FROM FLIGHT SERVICE STATIONS IS NOW AN OPTION FOR FLIGHTS IN THE CARIBBEAN AREA BETWEEN MIAMI AND SAN JUAN;
- THE INTERIM VOICE RESPONSE SYSTEM, WHICH PROVIDES PILOTS ACCESS TO WEATHER REPORTS AND FORECASTS OVER THE TELEPHONE, IS NOW OPERATING IN 25 MAJOR POPULATION AREAS;
- SATELLITE WEATHER INFORMATION HAS BEEN PROVIDED TO THE EN ROUTE CENTERS AND FLIGHT SERVICE STATIONS;
- HIGH ALTITUDE EN ROUTE FLIGHT ADVISORY SERVICE RADIO FREQUENCIES WILL BE IMPLEMENTED BY 1989 AND WILL SUBSTANTIALLY REDUCE THE CONGESTION OF LOW-ALTITUDE ADVISORY FREQUENCIES, IMPROVING LOWER-ALTITUDE SERVICES--ESPECIALLY FOR GENERAL AVIATION; AND
- IN ORDER TO EASE CONTROLLER WORKLOADS AND YET HAVE CURRENT SIGNIFICANT METEOROLOGICAL INFORMATION EASILY OBTAINED BY PILOTS, WE ARE PROCEEDING WITH THE HAZARDOUS IN-FLIGHT WEATHER ADVISORY SYSTEMS OR HIWAS--A SYSTEM

THAT WILL BROADCAST SEVERE WEATHER REPORTS THROUGH NAVAID RADIOS NATIONWIDE BY THE END OF 1988.

HOWEVER, DESCRIBING A FEW OF THE THINGS THAT HAVE ALREADY BEEN DONE TELLS ONLY A SMALL PART OF THE STORY. THE DEPARTMENT OF TRANSPORTATION'S AND FAA'S COMMITMENT TO CARRYING OUT THE NATIONAL AIRSPACE SYSTEM PLAN OR NAS PLAN IS, AMONG OTHER THINGS, A COMMITMENT TO "WEATHERPROOFING" THE AIRWAYS BY THE YEAR 2000. THE OBJECTIVES SECTION OF THE PLAN ALSO REFERS VERY SPECIFICALLY TO THE REDUCTION OF WEATHER-RELATED ACCIDENTS.

ON SEVERAL OF THE NAS PLAN PROJECTS, WE ARE MOVING FORWARD IN CLOSE COOPERATION WITH NWS AND THE DEPARTMENT OF COMMERCE. THE RELATIONSHIP IS A CLOSE AND LONGSTANDING ONE BECAUSE THEY ARE THE SOURCE OF SO MUCH OF THE NECESSARY WEATHER DATA, AND THE JOINT PROGRAMS THAT ARE UNDERWAY NOW WERE NO GREAT DEPARTURE FROM THE CONNECTIONS THAT WE HAD ALREADY ESTABLISHED. NWS, NOAA, AND THE COMMERCE DEPARTMENT DESERVE THE HIGHEST PRAISE FOR THEIR EXCELLENT CONTRIBUTIONS TO THE AVIATION WEATHER SYSTEM.

SPECIFICALLY, WE ARE WORKING TOGETHER WITH NWS ON THE NEXT GENERATION WEATHER RADAR KNOWN AS NEXRAD. IT IS A NEW TECHNOLOGY DOPPLER RADAR THAT WILL REPLACE THE CURRENT NETWORK OF WEATHER RADAR SYSTEMS, PROVIDING AN NWS/FAA/DOD NATIONAL NETWORK OF 113 WEATHER RADARS. IN ADDITION, FAA IS RECEIVING 17 SYSTEMS MODIFIED FOR TERMINAL WINDSHEAR USE--WHICH I WILL DISCUSS LATER--AND DOD RECEIVES THE REMAINDER. BACK IN 1979, A DEVELOPMENT AND COST-

SHARING AGREEMENT FOR THE NETWORK WAS SIGNED BY FAA (WHICH WOULD INCUR 20 PERCENT OF THE COSTS), NWS (60 PERCENT OF THE COSTS), AND THE AIR FORCE (20 PERCENT). THE PROGRAM IS NOW IN THE PROTOTYPE PHASE, WITH RAYTHEON AND UNISYS COMPETING FOR A PRODUCTION AWARD.

TESTS WILL BE COMPLETED SHORTLY, AND THE CONTRACT AWARD FOR A LIMITED PRODUCTION OF THESE SYSTEMS WILL TAKE PLACE NEXT MONTH. AFTER THE FIRST 10 UNITS ARE MADE, A SATISFACTORY OUTCOME WOULD LEAD TO A DECISION TO PRODUCE THE FULL 165 UNITS, WITH SUCH A PRODUCTION RELEASE EXPECTED IN JULY 1988. SYSTEM DELIVERIES WILL BEGIN IN SEPTEMBER 1989 AND END IN MAY 1994. NOAA'S NATIONAL SEVERE STORMS LABORATORY IS DEVELOPING THE COMPUTER SUBROUTINE FOR GUST FRONT DETECTION, FOR USE WITH THE NEXRAD.

ALTHOUGH NEXRAD IS BASICALLY AN EN ROUTE WEATHER RADAR, DOT IS COMMITTED TO PROVIDING IMPROVED WEATHER RADAR FOR TERMINALS AS SOON AS POSSIBLE. THIS DECISION REFLECTS THE WIDELY SHARED CONCERN ABOUT WINDSHEAR--A SUDDEN CHANGE IN WIND SPEED OR DIRECTION--WHICH HAS BEEN IMPLICATED IN THE CRASHES OF A PAN AMERICAN 727 IN KENNER, LOUISIANA, AND OF DELTA FLIGHT 191 IN AUGUST 1985. AT LEAST 536 AIRLINE PASSENGERS AND CREWMEMBERS HAVE BEEN KILLED WORLDWIDE IN THE PAST DECADE IN ACCIDENTS WHERE WINDSHEAR IS THOUGHT TO HAVE BEEN A FACTOR. IN LIGHT OF THE ABOVE AND BECAUSE WINDSHEAR IS NOT ONLY ASSOCIATED WITH STORMS, IT WAS DETERMINED THAT THE FIRST 17 NEXRAD SYSTEMS RECEIVED BY FAA SHOULD BE RECONFIGURED WITH SOFTWARE APPROPRIATE TO AIRPORT TERMINAL AREAS. FAA WILL GET ONE NEXRAD UNIT OUT OF EVERY FIVE PRODUCED

AND INSTALL THEM AS TERMINAL NEXRADS AT THE MOST VULNERABLE AIRPORT LOCATIONS.

THE SOFTWARE FOR TERMINAL NEXRADS HAS BEEN DEVELOPED INDEPENDENTLY OF THE NEXRAD CONTRACT BY LINCOLN LABORATORY AND HAS ALREADY BEEN ASSESSED IN AN FAA WEATHER RADAR TEST BED IN MEMPHIS AND THEN IN HUNTSVILLE. THE SAME TEST BED IS OPERATING IN DENVER THIS SUMMER TO SEE HOW WELL THE TERMINAL NEXRAD SET-UP WORKS IN "DRY" MICROBURST SITUATIONS AND FOLLOW THAT WITH A FULL OPERATIONAL EVALUATION NEXT YEAR. TERMINAL NEXRAD DELIVERIES COULD BEGIN IN EARLY 1990 AND CONCLUDE IN 1992, WITH THE FIRST UNIT GOING TO FAA'S TECHNICAL CENTER IN ATLANTIC CITY. FAA IS WORKING VERY CLOSELY WITH THE NEXRAD JOINT SYSTEM PROGRAM OFFICE--HEADED BY THE DEPARTMENT OF COMMERCE--TO DEAL WITH ANY QUESTIONS AS THEY ARISE.

THE TERMINAL NEXRAD IS BASICALLY AN INTERIM SYSTEM TO PROVIDE WINDSHEAR DETECTION AT MAJOR AIRPORTS UNTIL THE TERMINAL DOPPLER WEATHER SYSTEM OR TDWR IS READY. THE COMPUTER SUBROUTINES OR ALGORITHMS ARE ESSENTIALLY THE SAME, THE HARDWARE IS SUPPOSED TO HAVE AN 80 PERCENT COMMONALITY BETWEEN THE TWO SYSTEMS. AS TDWR REPLACES TERMINAL NEXRADS, THEY WILL BE LEAPFROGGED TO NEW SITES AND CONVERTED BACK INTO EN ROUTE WEATHER RADARS. LIKE TERMINAL NEXRAD, TDWR WILL WARN CONTROLLERS AND THUS PILOTS OF HAZARDOUS WEATHER CONDITIONS NEAR THE AIRPORT, PARTICULARLY MICROBURSTS WITH ATTENDANT WINDSHEAR CONDITIONS AND GUST FRONTS. THE SCALE OF IMPLEMENTATION IS VERY DIFFERENT, HOWEVER. SERIOUS CONSIDERATION

IS BEING GIVEN TO PLACING TDWRS AT AS MANY AS 100 TERMINALS AROUND THE COUNTRY.

IN LATE 1988, FAA PLANS TO AWARD A CONTRACT FOR TDWRS, WITH THE FIRST INSTALLATION SLATED FOR 1992. WE BELIEVE THAT THE WORK ON PREDECESSOR SYSTEMS, SUCH AS TERMINAL NEXRAD, AND THE NEED TO GET THE CAPABILITY OPERATIONAL AS SOON AS POSSIBLE, WILL BE SUFFICIENT TO SUPPORT A MANAGEMENT DECISION TO ELIMINATE A REQUIREMENT FOR OPERATIONAL TESTING AND EVALUATION BEFORE THE PRODUCTION CONTRACT AWARD. WHILE WE RECOGNIZE THERE IS SOME PROGRAM RISK, A FULL-SCALE TEST COULD SET THE PROGRAM BACK TWO TO THREE YEARS AND POSTPONE REALIZATION OF THE RELATED SAFETY BENEFITS.

INCIDENTALLY, THE TDWR WILL NOT BURDEN CONTROLLERS WITH THE NEED TO INTERPRET METEOROLOGICAL DATA. THIS WILL BE ACCOMPLISHED THROUGH AUTOMATION, AND THE CONTROLLER WILL MERELY READ THE COMPUTER-GENERATED MESSAGE TO THE PILOT.

LET ME EMPHASIZE AT THIS POINT THAT, TO THE EXTENT THERE HAVE BEEN SOME DELAYS IN NEXRAD, TERMINAL NEXRAD, AND TDWR, THOSE DELAYS HAVE RESULTED PRIMARILY FROM TECHNICAL OBSTACLES--MOSTLY IN THE SOFTWARE DEVELOPMENT AREA. WHAT PROBLEMS THERE WERE HAVE HAD VERY LITTLE TO DO WITH BUDGETARY CONSTRAINTS OR PROCUREMENT HURDLES, NOTWITHSTANDING FREQUENT ALLEGATIONS TO THE CONTRARY. WE ARE, AND HAVE BEEN, DEDICATED TO THE RAPID AND SUCCESSFUL DEPLOYMENT OF THIS TECHNOLOGY. WE ARE WORKING INTERNALLY TO ENSURE THAT WE ACQUIRE THIS CAPABILITY USING STEAMLINED PROCUREMENT TECHNIQUES.

TDWR IS PRESENTLY FACING A BUDGETARY OBSTACLE, HOWEVER. OUR REQUEST FOR $130 MILLION IN FY 1988 HAS BEEN REDUCED IN THE HOUSE APPROPRIATIONS SUBCOMMITTEE MARK-UP TO THE $10 MILLION LEVEL. THIS AMOUNT IS NOT ADEQUATE FOR A CRITICALLY IMPORTANT SAFETY PROJECT THAT SHOULD NOT BE SUBJECT TO UNNECESSARY DELAY. WITHOUT APPROVAL OF OUR ORIGINAL REQUEST FOR TDWR, WE WILL NOT BE ABLE TO AWARD A CONTRACT IN FY 1988, AS IS CURRENTLY PLANNED. THE SECRETARY IS EXTREMELY CONCERNED ABOUT THIS PROGRAM CUT.

GROUND-BASED WINDSHEAR SENSORS ARE NOT LIMITED TO TERMINAL NEXRAD AND TDWR. THE TDWR, WHICH CAN DETECT WINDSHEARS AT FARTHER DISTANCES AND HIGHER ALTITUDES WILL BE COMPLEMENTARY TO THE LOW LEVEL WINDSHEAR ALERT SYSTEM OR LLWAS, WHICH WAS INITIATED IN 1975. A STANDARD SYSTEM OF 6 SENSORS THAT HAS ALREADY BEEN INSTALLED AT NUMEROUS AIRPORTS, WITH LLWAS COVERAGE PLANNED FOR A TOTAL OF 110 AIRPORTS. THE REMAINING 11 AIRPORTS WILL HAVE SUCH COVERAGE BY THE END OF 1987. LLWAS SYSTEMS WILL ALSO BE ENHANCED WITH AN ADDITIONAL 5 SENSORS AND BETTER PROCESSING AND DISPLAY CAPABILITIES. THE ENHANCED LLWAS WILL REPORT WINDSHEARS IN TERMS OF EXPECTED LOSS OR GAIN OF AIRSPEED--A FORMAT THAT WILL BE EASIER. FOR PILOTS TO USE. AN OPERATIONAL TEST AND EVALUATION OF THE ENHANCEMENTS IS UNDERWAY THIS SUMMER IN DENVER. COMPLETION OF THE ENHANCED LLWAS PROGRAM IS SCHEDULED FOR THE END OF 1990.

WINDSHEAR--PARTICULARLY THAT STEMMING FROM MICROBURSTS--IS SUCH A SERIOUS THREAT THAT RELAYING ON GROUND-BASED SENSORS WOULD NOT BE

SUFFICIENT. PRECISELY BECAUSE NO ONE APPROACH COULD SOLVE THE PROBLEM BY ITSELF, FAA HAS BEEN PURSUING A COMBINATION OF STRATEGIES--GROUND-BASED SENSORS, WEATHER PREDICTION, AND AIRBORNE ALERT AND GUIDANCE EQUIPMENT. THE VARIOUS PROJECTS IN THESE AREAS ARE ALL REFLECTED IN FAA'S INTEGRATED WIND SHEAR PROGRAM, WHICH WAS APPROVED BY ADMINISTRATOR ENGEN IN MARCH.

WITH RESPECT TO AIRBORNE WINDSHEAR GUIDANCE, FAA HAS PROVIDED A TRAINING PROGRAM--DEVELOPED BY THE BOEING COMPANY AND OTHERS--TO 600 AIRLINES AND RELATED GROUPS. THE PURPOSE IS TO TRAIN PILOTS FOR RECOGNITION AND AVOIDANCE OF WEATHER CONDITIONS THAT CAUSE WINDSHEAR AND TO EMPHASIZE COCKPIT PROCEDURES WHEN A WINDSHEAR IS EXPERIENCED. ON JUNE 1, THE FAA ALSO PROPOSED A REGULATION TO REQUIRE LARGE JET AIRLINERS TO HAVE EQUIPMENT THAT WILL TELL PILOTS WHEN THEY HAVE ENCOUNTERED A WINDSHEAR AND HOW TO ESCAPE IT. SOME VERSIONS OF THE NEW EQUIPMENT HAVE PREVIOUSLY RECEIVED FAA CERTIFICATION. IN ADDITION, THE PROPOSAL WOULD REQUIRE AIRLINE FLIGHT CREWS TO RECEIVE GROUND SCHOOL AND SIMULATOR TRAINING IN WIND SHEAR RECOGNITION AND RECOVERY PROCEDURES USING THE EQUIPMENT.

ALSO WITH REGARD TO AIRBORNE EQUIPMENT, FAA AND NASA HAVE ENTERED IN TO AN AGREEMENT, UNDER WHICH THE TWO AGENCIES WOULD DEVELOP THE SYSTEM REQUIREMENTS FOR "FORWARD-LOOKING" WINDSHEAR SENSORS (I.E., DOPPLER RADAR AND DOPPLER LIDAR) FOR AIRCRAFT. THESE SENSORS WOULD WORK ON AIRCRAFT BY LOOKING AHEAD AND SENSING HAZARDOUS WINDS BEFORE IT ENTERED THEM. WITH THESE DETECTORS ON BOARD, THE

AIRCRAFT WOULD BE ABLE TO REJECT A LANDING OR TAKE-OFF BEFORE THE AIRCRAFT ENTERED THE HAZARDOUS AREA. THE AGREEMENT WILL BE IN EFFECT FOR FIVE YEARS, UNTIL SEPTEMBER 1991. THIS PROGRAM HAS SEVERAL OTHER ASPECTS--ALL RELATED--INCLUDING THE IMPROVEMENT OF EXISTING DETECTION SYSTEMS, IMPROVEMENTS THAT CAN BE MADE IN FLIGHT GUIDANCE FOR PILOTS DURING WINDSHEAR RECOVERY ATTEMPTS, AND THE CONTINUING CHARACTERIZATION OF THE WINDSHEAR HAZARD. THE WORK IS BEING CONDUCTED IN CONJUNCTION WITH AIRBORNE EQUIPMENT MANUFACTURERS SO THAT PROGRAM RESULTS WILL BECOME IMMEDIATELY AVAILABLE TO INDUSTRY.

OUR COOPERATIVE TIES WITH NWS THAT I MENTIONED EARLIER HAVE EXTENDED TO ANOTHER PROJECT AS WELL. THE AUTOMATED WEATHER OBSERVING SYSTEM OR AWOS IS A GROUND-BASED DEVICE WITH MULTIPLE SENSORS FOR RECORDING REAL-TIME SURFACE OBSERVATIONS OF VARIOUS WEATHER PARAMETERS. FAA'S CONTRACT FOR 206 SUCH SYSTEMS FOR USE ON NON-TOWERED AIRPORTS HAS BEEN TERMINATED DUE TO CONTRACTOR PERFORMANCE PROBLEMS AND SCHEDULE SLIPPAGE. WE HAVE DECIDED INSTEAD TO PROCEED WITH THE PROCUREMENT OF AROUND 160 COMMERCIAL AVAILABLE AWOS UNITS, AGAIN FOR NON-TOWERED LOCATIONS. WE HAVE ALSO PREPARED A MEMORANDUM OF UNDERSTANDING WITH NWS FOR A JOINT FAA/NWS AWOS PROCUREMENT. FAA WILL PROVIDE ALL CAPITAL AND OPERATIONS FUNDS FOR OVER 500 AWOS UNITS FOR BOTH TOWERED AND NON-TOWERED LOCATIONS, WHILE NWS WILL BE RESPONSIBLE FOR BUYING, INSTALLING, OPERATING, AND MAINTAINING THAT EQUIPMENT. WE ARE OPTIMISTIC THAT THIS ARRANGEMENT WILL PRODUCE QUALITY WEATHER INFORMATION AND FULLY MEET THE NEEDS OF THE AVIATION COMMUNITY.

OVER THE LONGER ONE, CONTINUED RELIANCE ON HUMAN OBSERVERS WOULD BE COSTLY AND PRECLUDE TIMELY AND ACCURATE WEATHER DATA COLLECTION AT A NUMBER OF AIRPORTS.

I MIGHT NOTE HERE THAT OUR LINK (AND THE AVIATION COMMUNITY'S) LINK WITH NWS--THE KANSAS CITY WEATHER MESSAGE SWITCHING CENTER--WILL BE REPLACED BY THE WEATHER MESSAGE SWITCHING CENTER REPLACEMENT UNITS LOCATED AT SALT LAKE CITY AND ATLANTA. THESE WILL INTERFACE WITH THE NATIONAL AIRSPACE DATA INTERCHANGE NETWORK, OR NADIN, WHICH IS THE DIGITAL COMMUNICATIONS SYSTEM FOR THE NATIONAL AIRSPACE SYSTEM.

THE CENTRAL WEATHER PROCESSOR OR CWP IS YET ANOTHER NAS PLAN UNDERTAKING. CWP IS A COMPUTERIZED SYSTEM FOR EN ROUTE CENTERS THAT WILL ACCEPT INFORMATION FROM THE NEXRAD RADARS AND METEOROLOGICAL PRODUCTS FROM NWS, PROCESS WHAT COMES IN, AND DISTRIBUTE IT TO APPROPRIATE PARTIES. NASA'S JET PROPULSION LABORATORY IS THE PRIME CONTRACTOR FOR CWP, A PROTOTYPE OF WHICH WILL ENTER THE TESTING PHASE IN 1990.

RECIPIENTS OF CWP DATA WILL, OF COURSE, INCLUDE METEOROLOGISTS AND WEATHER COORDINATORS IN CENTER WEATHER SERVICE UNITS. THE METEOROLOGIST WILL UTILIZE THE INFORMATION TO PREPARE AVIATION SHORT-TERM FORECASTS AND SEVERE WEATHER ADVISORIES. IN ADDITION, HE OR SHE WILL GENERATE GRAPHICAL PRODUCTS IDENTIFYING WEATHER HAZARDS. THE PROCESSED PRODUCTS GENERATED BY THE METEOROLOGIST AND BY AUTOMATIC ALGORITHMS WILL BE PROVIDED TO THE CONTROLLER AS

AN OVERLAY ON THE AIR TRAFFIC CONTROL DISPLAY AND TO THE PILOT VIA THE MODE S DATA LINK.

THE MODE S DATA LINK PROGRAM WILL ENABLE US TO TRANSMIT HAZARDOUS WEATHER INFORMATION DIRECTLY INTO THE COCKPIT AND THUS ELIMINATE THE CONTROLLER FROM THIS TIME-CRITICAL LOOP. COUNTERPART AVIONICS WILL BE NECESSARY FOR THE AIRLINES AND SOME OTHER AIRCRAFT OPERATORS TO BENEFIT FROM MODE S DATA LINK. NEVERTHELESS, THE EFFICIENCIES SEEM PROMISING, AND THE EQUIPMENT ALSO OFFERS AIR TRAFFIC CONTROL OPTIONS THAT DID NOT EXIST BEFORE. THE FIRST MODE S SYSTEM IS SCHEDULED TO BE OPERATIONAL IN 1990.

A WEATHER COMMUNICATION PROCESSOR WILL SERVE AS THE INTERFACE BETWEEN THE MODE S DATA LINK, THE CENTRAL WEATHER PROCESSOR, AND THE FLIGHT SERVICE DATA PROCESSING SYSTEM. THIS PROCESSOR IS PLANNED TO BE INSTALLED STARTING IN 1990. INITIALLY, IT WILL PROVIDE TERMINAL FORECAST SURFACE OBSERVATIONS, WINDS ALOFT, PILOT REPORTS, RADAR SUMMARIES IN TELETYPE FORMAT, AND HAZARDOUS WEATHER NOTICES.

IN ADDITION TO THE EFFORTS I HAVE JUST DESCRIBED, DR. JOHN MCCARTHY OF THE NATIONAL CENTER FOR ATMOSPHERIC RESEARCH, WORKING WITH A GROUP OF TECHNICAL EXPERTS, COMPLETED A REPORT DURING 1986 THAT PROVIDED A NUMBER OF RECOMMENDATIONS COVERING THE AREAS OF PILOT WEATHER TRAINING AND NEAR-TERM IMPROVEMENTS IN FORECASTING, PARTICULARLY AS THEY RELATE TO SEVERE WEATHER HAZARDS AND UPPER WINDS. THIS REPORT IS PRESENTLY BEING REVIEWED BY THE AVIATION

USER GROUPS. THEIR COMMENTS WILL BE THE BASIS OF THE ACTION PLAN THE FAA WILL DEVELOP AND PROVIDE TO NWS.

I WOULD BE REMISS IF MY TESTIMONY FAILED TO MENTION FAA'S AUTOMATED FLIGHT SERVICE STATION PROGRAM, UNDER WHICH WHAT WERE OVER 300 FLIGHT SERVICE STATIONS SERVING THE U.S. ARE BEING CONSOLIDATED INTO AUTOMATED FACILITIES. AT THE CONCLUSION OF THIS MAJOR UNDERTAKING, WE WILL HAVE 61 AUTOMATED FLIGHT SERVICE STATIONS OR AFSSS WITH DISPLAY AND PROCESSING ABILITIES THAT GO FAR BEYOND THAT FOUND IN THE OLD FLIGHT SERVICE STATIONS. THIS IS CRITICALLY AN IMPORTANT PROGRAM AND ONE ON WHICH WE HAVE CONSULTED AND COOPERATED WITH THE CONGRESS ON A CONTINUING BASIS. WE HAVE BEEN COMPLYING WITH DIRECTIVES RECEIVED IN THIS CONNECTION AND WORKING TO ENSURE THAT THE NEW FACILITIES DO INDEED OFFER EQUAL OR BETTER SERVICE TO OUR AVIATION USERS. THE AUTOMATION ASPECT WILL IN FACT ENHANCE OUR WEATHER DISSEMINATION CAPABILITIES.

FINALLY, 100 AIRPORT SURVEILLANCE RADARS OR ASR-9S--WITH DEDICATED WEATHER CHANNELS WILL BE INSTALLED THAT WILL GIVE CONTROLLERS WEATHER INFORMATION CHANNELS ON THEIR RADAR SCOPES. INSTALLATION OF THESE RADARS WILL BEGIN THIS YEAR AND WILL BE COMPLETED IN 1991. THIS PROGRAM WILL PROVIDE IMPROVED TERMINAL RADAR SERVICES, INCLUDING WEATHER, TO OVER 86 PERCENT OF U.S. ENPLANED PASSENGERS.

IN A SIMILAR VEIN, THE LONG-RANGE RADARS--KNOWN AS AIR ROUTE SURVEILLANCE RADARS--ARE BEING MODIFIED TO GENERATE THREE LEVELS OF WEATHER INTENSITY CONTOURS. THESE THREE LEVELS WILL CORRELATE

WITH THREE OF THE SIX STANDARD NATIONAL WEATHER SERVICE INTENSITY LEVELS. THIS CAPABILITY WILL BE IMPLEMENTED AT 20 EN ROUTE CENTERS BY MID-1989. THE MODIFICATION WILL PROVIDE REAL-TIME PRECIPITATION CONTOUR INFORMATION TO THE EN ROUTE CONTROLLERS.

YOU MAY ALSO BE FAMILIAR WITH ANOTHER RADAR SYSTEM--AIRPORT SURFACE DETECTION EQUIPMENT OR ASDE-3. ASDE-3 IS USED BY TOWER CONTROLLERS TO CONTROL AIRCRAFT AND VEHICLE MOVEMENTS ON THE AIRPORT SURFACE IN PERIODS OF POOR VISIBILITY. OVER 30 AIRPORTS ARE SCHEDULED TO RECEIVE THIS SHORT-RANGE RADAR, WHICH PROMISES TO MORE THAN LIVE UP TO EXPECTATIONS OF OUR AIR TRAFFIC PERSONNEL.

THIS COMPLETES MY PREPARED STATEMENT, MR. CHAIRMAN. I OR THE TECHNICAL EXPERTS FROM FAA WHO ACCOMPANIED ME WOULD BE PLEASED TO RESPOND TO ANY QUESTIONS YOU OR MEMBERS OF THE SUBCOMMITTEE MAY HAVE AT THIS TIME.

Mr. **Oberstar**. With that, the subcommittee stands adjourned.

[Whereupon, at 7:20 p.m., the subcommittee adjourned.]

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